

THE
Practical SURVEYOR;

Shewing, Ready and Certain

METHODS

FOR

Measuring, Mapping *and* Adorning

All Sorts of

LANDS and WATERS,

By the several

INSTRUMENTS used for this Purpose;

Particularly, Of

A New THEODOLITE;

Very convenient to be used by those who are resolved
to be ACCURATE, as well as EXPEDITIOUS.

Together with

The Use of the same THEODOLITE, in
drawing the PERSPECTIVE APPEARANCE of a
GENTLEMAN'S SEAT, without MEASURING one
SINGLE LENGTH, at one setting down of the In-
strument, the Picture having any given Position.

Also, Its Use in LEVELLING, Measuring Timber
Standing; and, by a Sliding Rule improved, all
Timbers, Shrubs, &c.

Extracted from the Works of the most Experienced Artists,

By JOHN HAMMOND.

L O N D O N:

Printed for T. HEATH, Mathematical Instrument-
Maker, at the Hercules, next Door to the Fountain
Tavern in the Strand: M. DCC. XXV.

Practical SURVEYOR

Showing Ready and Certain

METHODS

FOR

Measuring, Mapping, and

All sorts of

LANDS and WATERS

By the several

Experiments and

Observations of

A NEW THEODOLITE

Which is more accurate than any other

Instrument with

the use of the THEODOLITE

By the use of the THEODOLITE, the Surveyor is enabled to measure the Area of any Piece of Land, without the Assistance of a Chain, and to find the Length and Breadth of any Piece of Land, without the Assistance of a Chain, and to find the Area of any Piece of Land, without the Assistance of a Chain.

And to find the Length and Breadth of any Piece of Land, without the Assistance of a Chain, and to find the Area of any Piece of Land, without the Assistance of a Chain.

By JOHN H. A. M. D.

Printed for T. H. A. M. D. at the



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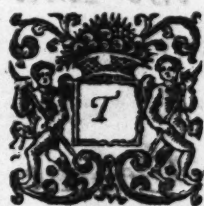


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THE PREFACE.



THE Design of the following Tract, is to shew, as it were by Inspection, the whole Business of a Land Surveyor; without the Confusion of useless Curiosities, or the Omission of any of the Problems necessary to the Practice: And in so plain, tho' concise, a Manner, that one of a common Capacity, may, hereby, together with a little Reflection on the Instruments for this Purpose

vi The PREFACE.

used, acquaint himself with this useful Art.

It is extracted from those Writers, who have been look'd upon as good Judges, as well as frequent and ingenious Professors; and it is hop'd, not without Reason, That it will answer the End for which it is designed.

First, Here are some Geometrical Problems, absolutely necessary to every Person who undertakes Surveying.

Then, a particular and very exact Description of the several Instruments: And a just Comparison of them together; particularly the various Sorts of Theodolites: With due Directions and Cautions

THE PREFACE

Cautious in their Management, according to their several Kinds; in order to prevent Errors and Mistakes, as well in the taking Observations (and correcting before we leave the Field) as in plotting and laying down the Draught.

Thirdly, An easy Way to cast up the Content of any Land, whether right-lined, or irregularly waving, often without marking or staining the Draught, or drawing one single Line.

The Use of the THEODOLITE, as now improved, by a large Example, shewing its Use and Advantages, above all other Instruments, heretofore used, in surveying large Parcels of Lands of different

vi The PREFACE

different Kinds ; and many Varieties often met with by the Undertaker. And a very regular and easy Way in keeping the Order of a Field Book, to prevent the Faults incident to the Memory ; and full and plain Directions to plot by the same. This from Mr. Cunn's Appendix.

Afterwards follows the Use of this Theodolite, in allowing for Ascents and Descents, by finding the Horizontal Lines of those that are ascending ones, absolutely necessary to the due Performance of a just Survey. And this BY INSPECTION, WITHOUT ANY CALCULATION. Together with its Application to the Measuring of Heights, with the same Ease.

Then

THE PREFACE i

Then the *Practical Measurement*, as well of *Timber*, whether round or squared, equally or unequally, as of *Stone*, &c. by the *Sliding Rule*, as now improved, and fitted for all *Timbers*, tho' never so large, as well as the *smallest Shrubs* or *Sticks*, that are often sold by *Measure*. And this even BY ONE SETTING OF THE RULE, without any other previous Preparation, than taking the *Dimensions*: In many Cases, scarce before practised.

Another Use of this New *Theodolite*, is in all Positions of the *Eye*, fitted to take the *Perspective Appearance* of *Houses*, *Gardens*, *Fortifications*, &c. with or without approaching the *Object*,

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ject, and without measuring any
one single Length.

Also a Method to Survey and
Plane those Sands, that are al-
ways under Water, by the same
Instrument.

Lastly, the Method to adjust,
and use the Water Level; with
due Precaution therein.



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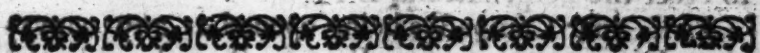
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THE Practical SURVEYOR.



Geometrical PROBLEMS.

PROB. I.

Upon a right Line given, how to erect another right Line, which shall be perpendicular to the right Line given.



THE right Line given is A B (fig. 1) upon which, from the Point E it is required to erect the Perpendicular E H.

Opening your Compasses at Pleasure to any convenient Distance, place one Foot in the assigned Point E, and with the other make the Marks C and D, equi-distant on each Side the given Point E. Then opening your Compasses again to any other convenient Distance, wider than the former, place one Foot in C, and with the other describe the Arch G G; also (the Compasses remaining at the same Distance) place one Foot in the Point D, and with the other describe the Arch F F.

F F: Then from the Point where these Two Arches intersect or cut each other, which is at H, draw the right Line HE, which shall be perpendicular to the given right Line AB, which was the Thing required to be done.

P R O B. II.

How to erect a Perpendicular upon the End of a right Line given.

L E T AB (fig. 2.) be a right Line given, and from the End thereof, at B, let it be required to erect the Perpendicular BF.

First, your Compasses being opened at any convenient Distance, place one Foot in B, and with the other make the Mark C, the Compass Point resting in C; with the other Foot, make the Mark D, in the given Line AB; and then lay a Ruler from D to C, and draw the Line DE, making CE equal to CD. Lastly, from B, through E, draw the Line BF, which shall be perpendicular to the given Line AB.

P R O B. III.

To divide a given right Line into Two equal Parts.

L E T AB (fig. 3.) be a right Line given, to be divided into Two equal Parts.

First, from B and C the Ends of the same, with any Distance greater than the Half of the said Line, describe Arches above and below, cutting one another in the Points D and F: Lastly, draw DF, it will cut AB into Two equal Parts in H, as required.

FIG. 3.

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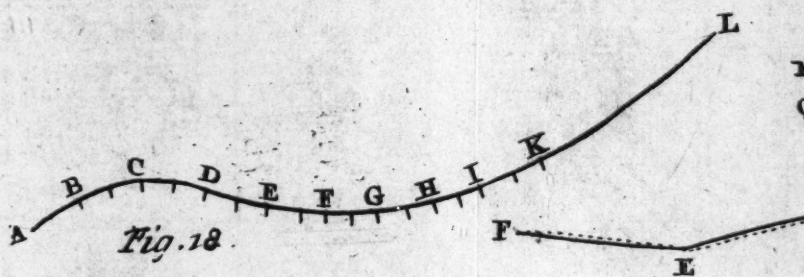
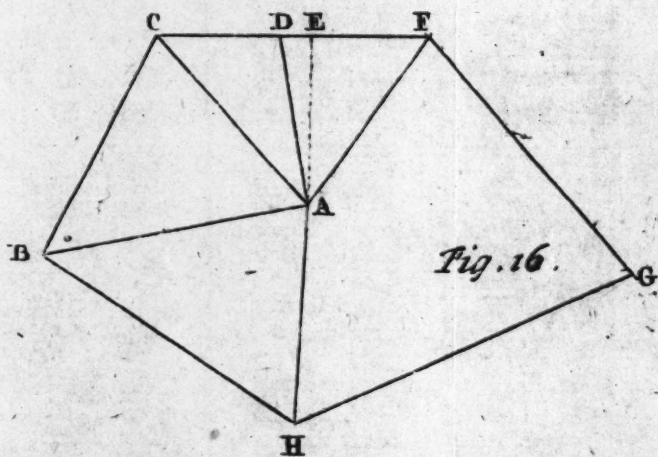
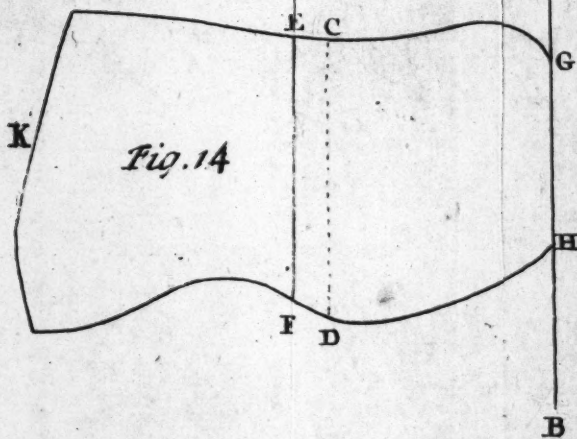
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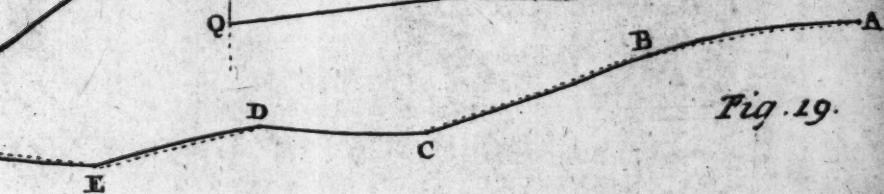
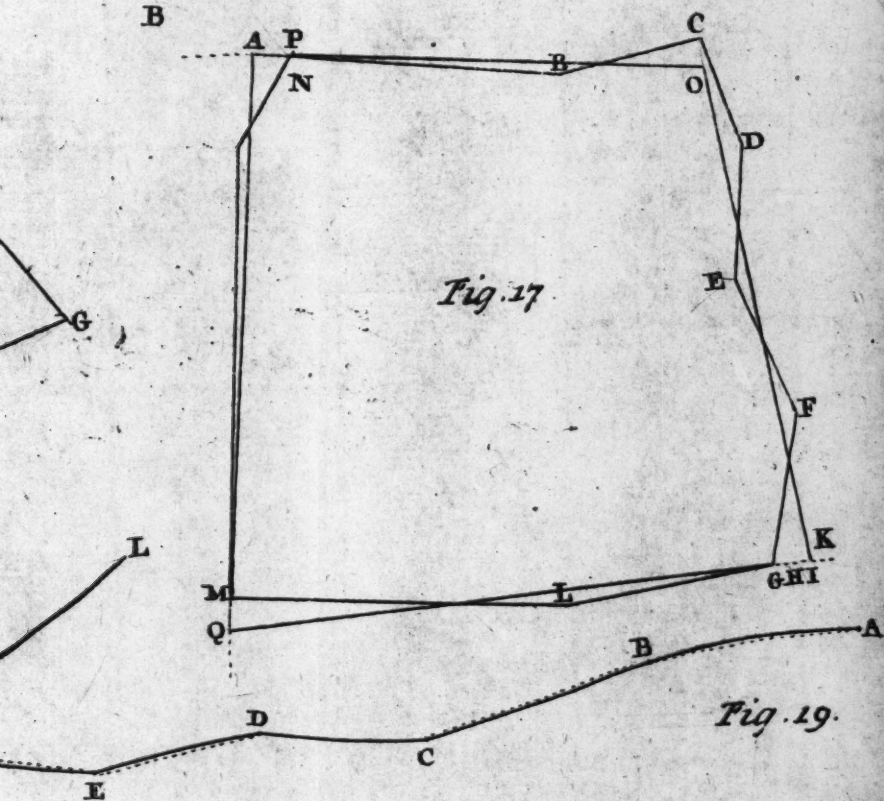
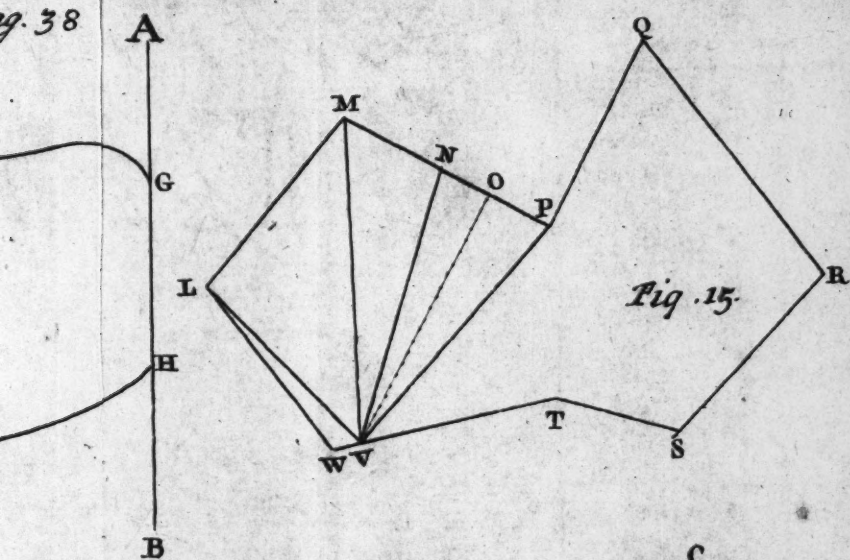
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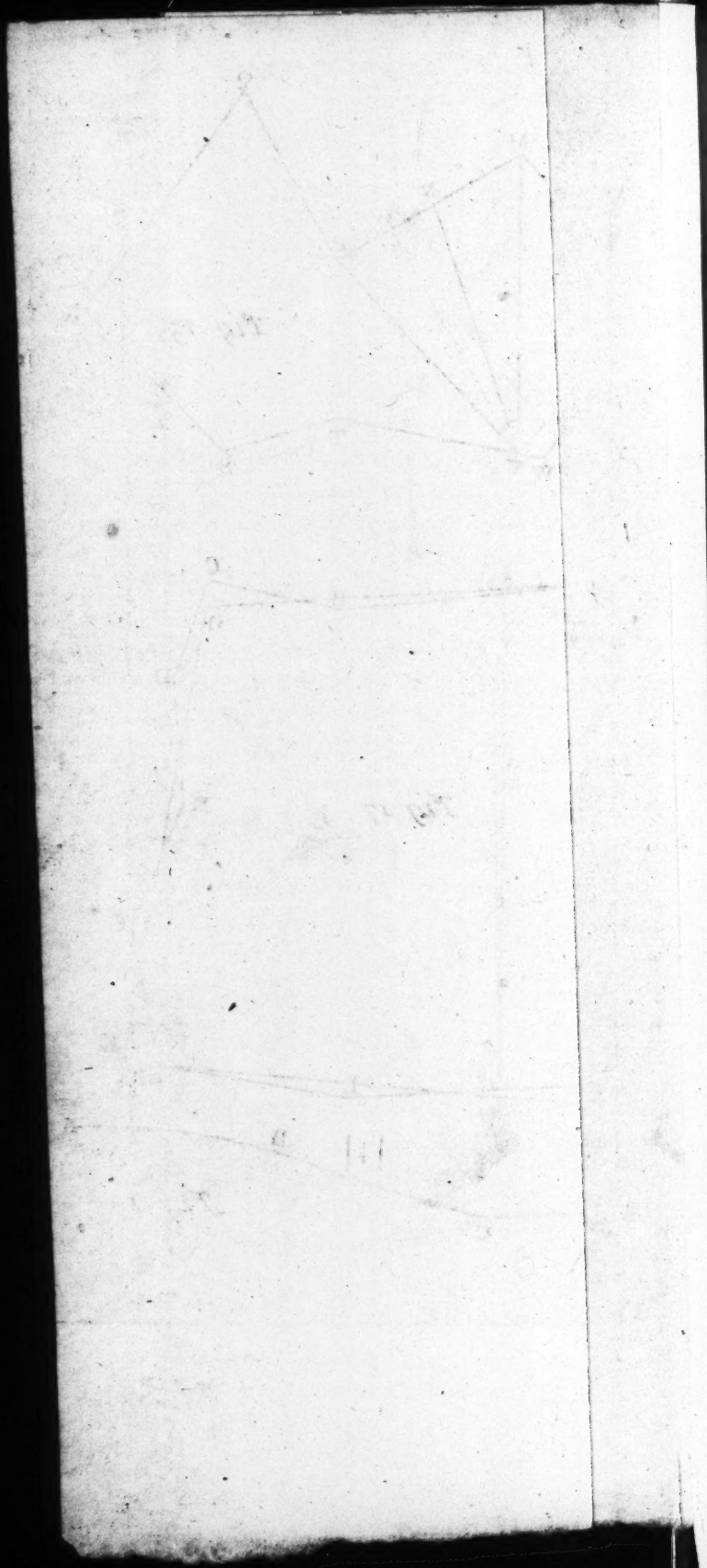
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P R O B. IV.

How to let fall a Perpendicular from any Point assigned, upon a right Line given.

THE Point given (fig. 4.) is C, from which Point it is required to draw a right Line, which shall be perpendicular to the given right Line A B.

First, from the given Point C, to the Line A B, draw a Line by Chance, as C E, which divide into Two equal Parts in the Point D: Then placing one Foot of the Compasses on the Point D, with the Distance D C, describe the Semicircle C F E, cutting the given Line A B in the Point F. Lastly, if from the Point C, you draw the right Line C F, it shall be a Perpendicular to the given Line A B, which was required.

P R O B. V.

How to make an Angle equal to an Angle given.

LET the Angle given be A C B (fig. 5.) and let it be required to make another Angle equal thereunto.

First, draw the Line E F at Pleasure; then, upon the given Angle at C, (the Compasses opened to any Distance) describe the Ark A B; also upon the Point F, (the Compasses unaltered) describe the Ark D E: Then take with your Compasses the Distance A B, and set the same Distance from E to D. Lastly, draw the Line D F, so shall the Angle D F E be equal to the given Angle A C B.

P R O B. VI.

A right Line being given, how to draw another right Line which shall be parallel to the former, at any Distance required.

THE Line given is *AB*, (*fig. 6.*) unto which it is required to draw another right Line parallel thereunto, at the Distance *M N*.

First, open your Compasses to the Distance *M N*, then placing one Foot in *A*, with the other describe the Ark *C*; also place one Foot in *B*, and with the other describe the Ark *D*. Lastly, draw the Line *CD*, so that it may only touch the Arks *C* and *D*; so shall the Line *CD* be parallel to the Line *AB*, and at the Distance *M N*, as was required.

P R O B. VII.

A right Line being given, how to draw another right Line parallel thereunto, which shall also pass through a Point assigned.

LET *AB* (*fig. 7.*) be a Line given, and let it be required to draw another Line parallel thereunto, which shall pass through the given Point *C*.

First, take with your Compasses the Distance from *A* to *C*, and placing one Foot thereof in *B*, with the other describe the Ark *DE*; then take in your Compasses the whole Line *AB*, and placing one Foot in the Point *O*, with the other describe the Ark *FG*, crossing the former Ark *DE* in the Point *H*. Lastly, if you draw the Line *CH*, it shall be parallel to *AB*.

These Two last PROBLEMS may be more easily performed by a parallel Ruler.

P R O B

P R O B. VIII.

To divide a Line into any Number of equal Parts.

LET *AB* (*Fig. 8.*) be a right Line given, and let it be required to divide the same into four equal Parts.

First, from the End of the given Line *A*, draw the Line *AC*, making any Angle; then from the other End of the given Line, which is at the Point *B*, draw the Line *BD* parallel to *AC*, (or make the Angle *ABD* equal to the Angle *CAB*) then upon the Lines *AC* and *BD*, set off any three equal Parts (which is one less than the Number of Parts into which the Line is to be divided) on each Line, as 1, 2, 3; then draw Lines from 1 to 3, from 2 to 2, and from 3 to 1, which Lines, crossing the given Line *AB*, shall divide it into four equal Parts, as was required.

P R O B. IX.

Any three right Lines being given, so that the two shortest together be longer than the third, to make thereof a Triangle.

LET it be required to make a Triangle of the three Lines *C*, *B*, and *A*, (*Fig. 9.*) the two shortest whereof, viz. *A* and *B* together, are longer than the third Line *C*.

First, draw the Line *DE* equal to the given Line *B*, then take with your Compasses the Line *A*, and setting one Foot in *E*, with the other describe the Arch *HG*; also take the given Line *C* in your Compasses, and placing one Foot in *D*, with the other describe the Arch *KF*, cutting the former Arch *HG* in the Point *O*. Lastly, if from the Point *O*, you draw the Lines *OE* and *OD*, you shall constitute

constitute the Triangle O D E, whose Sides shall be equal to the three given Lines, A, B, C.

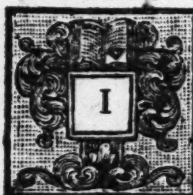
In like manner a Triangle l m n may be made equal to L M N, another given. See Fig. 10.

Also any rectilineal Figure a b c d e f g, equal to any other rectilineal Figure A B C D E F G, by making the Triangles a b g, b g f, b f e, b c e, c e d, respectively equal to the Triangles A B G, B G F, B F E, B C E, C E D. See Fig. 11.



S E C T. I.

Of INSTRUMENTS used in Surveying Land.



I NSTRUMENTS used in Surveying are, either to measure, or lay down the Lengths of Lines, or their Positions,

The most proper Instruments for measuring Lengths, in Towns, Streets, or any other Buildings, are 5 Foot and 10 Foot Rods, and a Chain of 50 Foot long; for Fields and Woods, a Chain of 66 Foot or 4 Poles, consisting of 100 Links, each containing 7 Inches and $\frac{1}{2}$; and a Rod, whose Length is equal to $\frac{1}{4}$ Part of the Chain, that is 10 Links, or 6 Foot 7 Inches and $\frac{1}{2}$: For Roads, the Wheel.

The Instruments used for taking the Positions of Lines are of two kinds.

With some we take the Position of a Line, by the Angle which that Line makes with the Meridian, using a Box and Needle; as with the *Theodolite*, the *Circumferentor*, the *Plain Table*, the *Perambulator*, the *Peraſtor*, &c. and this is usually called the *Bearing of the Line*.

With

With others we take the Position by the Angle that the Line makes with any other given in Position; as with the Limb of the *Theodolite*, the Limb of the *Semicircle*, the *Frame* of the *Plain Table*, the *Bevel*, the *Chain*, or *Rods*.

All other Instruments either differ from these only in their Names, or else are contained in them.

But with some of these Instruments, very conveniently we take the Position in both manners, at one Observation; as with the *Theodolite*, the *Semicircle*, or the *Plain Table*.

With some of these Instruments we take the Angle itself, as with the *Bevel*, or with the *Plain Table* covered with a Sheet of Paper; and with others, we express the relative Quantity of that Angle by Numbers. So when we use the Chain, we express the Angle by Sextants, Links and Tenth Parts of a Link; when we use Rods, we express it by Sextants, and centesimal Parts of a Rod; and when we use other Instruments, we express the Angles by Degrees and Minutes.

We also observe, that of *Theodolites* and *Semicircles* there are various Kinds; in some the Box is fix'd to the Plate, in others to the Index. And the working with each of these varies according to the Manner of their Numbering.

As for Roads, the Wheel, with its Indices, shewing the Distance, and its Box and Needle with Sights shewing its Bearing or Position in respect of the Meridian, is an Instrument speedy and sufficiently exact; provided we reject the Breadth of the Road, and only regard the Bearing and Length.

Lastly, Instruments for plotting, are a Scale decimally divided the whole Length, close to both the Edges; and at every tenth Division numbered 0, 1, 2, 3, 4, &c. denoting Chains; the Numbering ordered that we may count either from the Right to the Left, or from the Left to the Right; and a *Protractor* always to be divided, numbered, and fitted to your Instrument.

For all *Circumferenzors* (either so distinctly, or used as such, viz. when contained in the *Theodolite*, *Semicircle*, or *Plain Table*) let the Numbers in the *Protractor* encrease contrary to those in the Box; but when the Box and Needle takes the Bearing, as the *Peractor* or *Perambulator* doth, the Numbers of the *Protractor* must encrease as those in the Box. And for the Limbs of all *Theodolites*, *Semicircles*, and *Plain Tables*, if the Circuit be made { according } to the Numbers on the Limb, the Numbers of the *Protractor* most conveniently encrease the { contrary } way with the Numbers on the Limb of the Instrument.



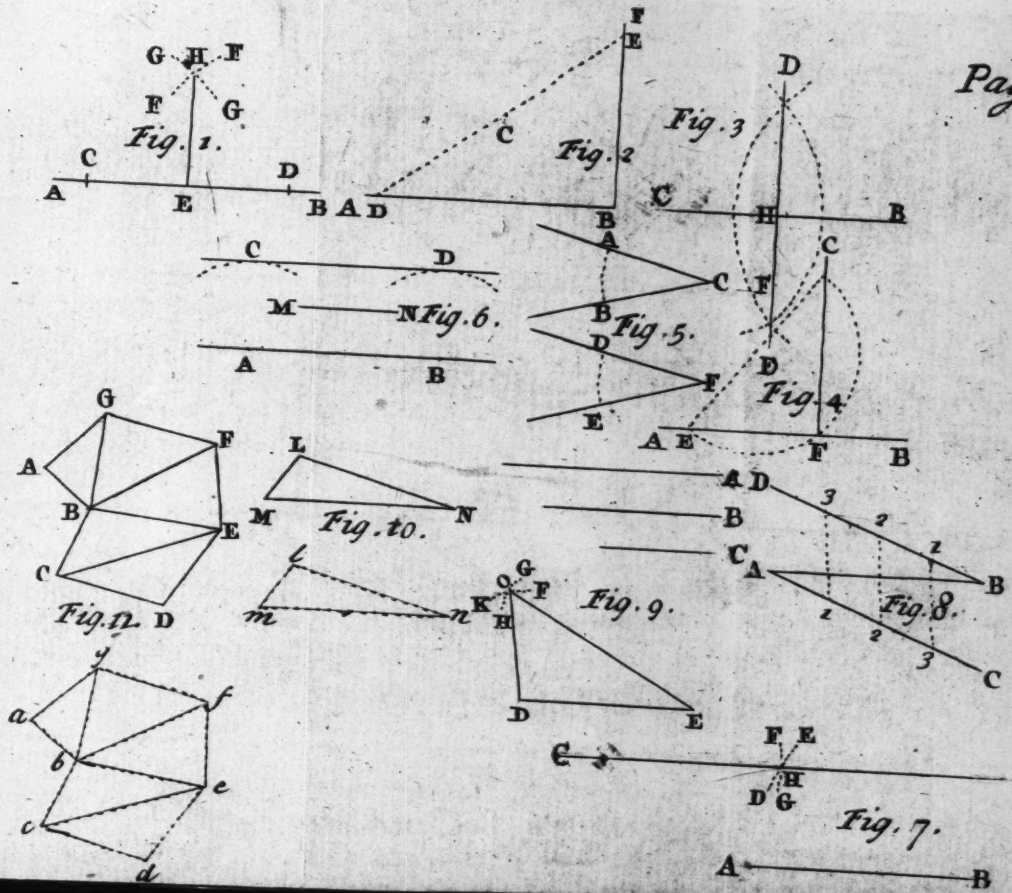
S E C T. II.

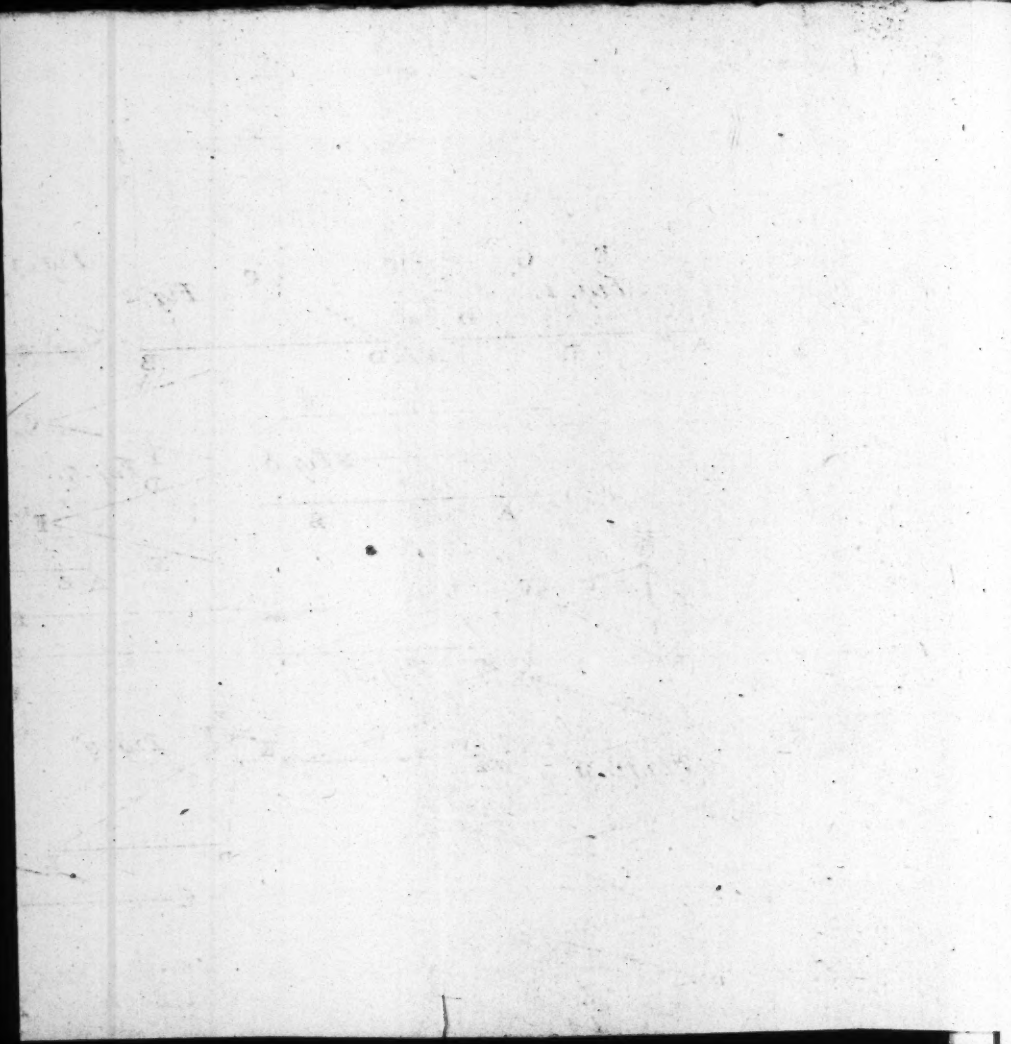
To observe the Position of a Line by any of the preceding Instruments.

I. By the *Circumferentor*.

THE Box of the *Circumferentor* is divided into 360 Degrees, and numbred in 4 Quarters, from the North and South both to the East and West, by the Figures 10, 20, 30, 40, 50, 60, 70, 80, 90; but these Divisions are also numbred from the North towards the East or West, all round, till they end at the North again, by the Figures 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, and so on to 360. Of these two ways of numbering, the latter is properly the *Circumferentor*, and the former the traversing Quadrants or Quarters.

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Now, if it be required to observe the Bearing of the Line A B (*Fig. 12.*) the Instrument standing at A; The Flower-de-luce being towards you, direct the Sights to B; and the South End of the Needle will point at 207 Degrees in the *Circumferentor*, and at S. W. 27, in the traversing Quadrants.

And if you were going round the Field, and so next to observe the Bearing of the Line B C; at B turn the Index about, the Flower-de-luce being towards you, till through the Sights you see the Hair cut C: then will the South End of the Needle point at 111, in the *Circumferentor*, (which is the Bearing, always counted from the North, and in these Examples indeed Eastward) and at S. E. 69 in the traversing Quadrants, which is the Bearing always counted from the North or South towards the East or West. Here we may Note, that the Bearing taken with the *Circumferentor* may be any Number of Degrees not exceeding 360, but that with the traversing Quadrants never exceeds ninety Degrees.

When you suspect the Needle doth not play well; direct your Index to your Mark, and note the Degrees pointed at by the Needle in a waste Piece of Paper; then with a clean Knife, or a Key, or any other polished bit of Steel, which hath touched a Loadstone, move the Needle, by applying it to the Box, and examine, when it hath settled again, what Degree it then points at, your Index being still directed to the preceding Mark; and if the Degrees are the same, they may be entred into the Field-Book; but if not, the Cap and Pin must be cleansed with some brown Paper and a little Puttey, and thereby freed of such Dust or Dampness as hath gotten to it; if, after all, the Needle doth not play freely, screw in a new Pin, or use another Needle, or do both; these Necessaries every Surveyor ought to have in his Pocket while he is in the Field.

If you suspect any Error in the Bearing of any Line already taken, arising from the Needle's being acted on by some hidden Magnetick Power, or from

your own Mistake in observing the Degrees pointed at; the Doubt may be cleared, and the Error corrected at the Station; thus,

Having come to B (Fig. 12.) the Flow-de-luce being from you, look back to A, and then will the South End of the Needle point at 207 Degrees in the *Circumferentor*, and at S. W. 27 Degrees in the traversing Quadrants; just as it did A.

Lastly, if you have no Reason to suspect the Needle, and it is most convenient to plot by it, the speediest way is to place the Instrument only at every other Angle, and there to take the Bearings of the two Lines constructing that Angle.

So, if you would observe the Bearings of the Lines of Fig. 13 first, place the Instrument at B, and with the Flower-de-luce from you, direct the Sights back to A, so the South End of the Needle will point at 207 Degrees in the *Circumferentor*, and at S. W. 27 Degrees in the traversing Quadrants, which is the Bearing of A B; then with the Flower-de-luce next you, direct the Sights to C, so the South End of the Needle will point at 111 Degrees in the *Circumferentor*, and at S. E. 69 Degrees in the traversing Quadrants, which is the Bearing of B C.

Now place the Instrument at D, the Flower-de-luce being from you, direct the Sights back to C, so the South End of the Needle will point at 44 Degrees 30 Minutes in the *Circumferentor*, and at N. E. 44 Degrees 30 Minutes in the traversing Quadrants, which is the Bearing of C D; and directing the Sights to E, the Flower-de-luce being towards you, the South End of the Needle will point at 102 Degrees 15 Minutes in the *Circumferentor*, and at S. E. 47 Degrees 45 Minutes in the traversing Quadrants.

In like manner work at F, &c. always keeping the Flower-de-luce from you, when you look backwards, and towards you when you look forwards; so will the South End of the Needle point at the Degrees of the Bearing in both Cases.

*To protract any Line whose Bearing is taken
by the Circumferentor.*

FIRST, draw Lines parallel to one another quite through the designed Draught, at Distances not exceeding the Breadth of the Diametrical Part of your *Protractor*, as in *Fig. 12.* and mark them with *N.* and *S.* for North and South; then lay the Center of the *Protractor* on *A* the Point given, representing the Station *A* in the Field, and, by Help of the Divisions continued beyond the Ends of the Diameter of the *Protractor*, lay the Diameter parallel to those North and South Lines, the beginning of the numbering Northwards, when the Degrees are fewer than 180, but Southwards when more; the *Protractor* being thus placed close to the Limb against 207, the Degrees of the Bearing, make a Mark, and to it draw the Line *A B*; and so will *A B* have a Bearing like to that, which you observ'd the Line *A B* to have in the Field. In like manner you may lay down the Bearing of any other Line, as *B C*; if you observe to lay the beginning of the numbering Northwards, when the Degrees are less than 180, and Southwards when more.

And if you would lay down the Bearing of any Line *A B* from any assigned Point *A*, with the traversing Quadrants; after you have drawn North and South Lines as before, the North being upwards, write East on the right Hand Side of the Map, and West on the Left. Now lay the Center of the *Protractor* and *Diameter* as before taught; save that instead of observing the Number of the Degrees, you turn the Limb of the *Protractor* Eastward, when the Bearing is *N. E.* or *S. E.* and Westward, when it is *N. W.* or *S. W.*

The *Protractor* being thus placed, against S. W. 27, make a Mark, and to it draw the Line A B, and so will A B have a Bearing like to that which A B was observed to have in the Field. In like manner you may lay down the Bearing of any other Line.

2. *With a Theodolite, both by the Limb, and by the Box and Needle.*

BEfore you engage in a Survey, you ought to consider the numbering of your Instrument; thus, when the Eye is conceived plac'd in the Center, consider whether the Numbers increase from the Left to the Right, or from the Right to the Left; or, according to the Farmer's familiar Phrase, whether the Numbers increase with or against the Sun's Motion.

And then observe, that with a *Theodolite*, whose Box is fix'd to the $\left\{ \begin{array}{l} \text{Plate} \\ \text{Index} \end{array} \right\}$ the Circuit is most conveniently made $\left\{ \begin{array}{l} \text{with} \\ \text{against} \end{array} \right\}$ the increasing of the Numbers; and the fix'd Sights shall always be directed to the $\left\{ \begin{array}{l} \text{next} \\ \text{last} \end{array} \right\}$ Station, and the Index to the $\left\{ \begin{array}{l} \text{last} \\ \text{next} \end{array} \right\}$ And then if you keep the Beginning or the Degrees towards you when you direct the fix'd Sights, and the Flower-de-luce towards you when you direct the Index; the Degrees cut by the End of the Index which is next you, are the Degrees of the Angle; and the Degrees pointed at in the Box by the South End of the Needle, give the Bearing of the next Length. And this Bearing will be, in all respects, the same with that taken with the *Circumferentor*; provided that the Box be divided and numbred like that of the *Circumferentor*.

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This double Observation is of great use to the Surveyor; for hereby he may either plot by the Angle or by the Bearing, or both, as he shall find most convenient; and also, he may prove his Observation before he moves his Instrument. For, of the Numbers expressing the Bearing of the Lines forming any Angle, if the lesser be subtracted from the greater, and the Remainder be $\left\{ \begin{array}{l} \text{increased} \\ \text{diminished} \end{array} \right\}$ by

180 Degrees when $\left\{ \begin{array}{l} \text{less} \\ \text{greater} \end{array} \right\}$ than 180, the Result will give either the Angle itself, or its Supplement to 360 Degrees.

When we use a *Theodolite* with a Box fix'd to the $\left\{ \begin{array}{l} \text{Plate} \\ \text{Index} \end{array} \right\}$ and the Numbers in the Box increase the $\left\{ \begin{array}{l} \text{same} \\ \text{contrary} \end{array} \right\}$ way with the Numbers on the Plate, as they generally do, or as I would chuse to have them; then a *Protractor* being numbred contrary to the Numbers in the Box, will be fitted to lay down the Plan, either by the Angles taken by the Limb, or by the Bearing taken by the Needle, or by both together, in order to prove the Truth of each other: And then also may the Truth of the Angle or Bearing be proved, before the Instrument is moved from the Station by either of the two following Rules.

If to the present Bearing be added 180 Degrees, and from the Sum you subtract the last Bearing; then the Remainder will be the present Angle.

And if to the present Angle you add the last Bearing, and from the Sum subtract 180; then will the Remainder be the present Bearing.

But if the Degrees to be subtracted are more than those from which they are to be subtracted; the latter must be increased by 360, and then subtract.

And if the Remainder be more than 360, then abate 360, and the Result gives the Degrees required.

So,

So, with a *Theodolite* that hath the Box fix'd to the Index, and the Numbers on the Plate, while the Eye is conceived placed in the Center, increase from the Left to the Right, but those in the Box the contrary way, and so most proper to work against the Sun: If you would take the Bearings of the Lines of *Fig. 12.* and if you would begin from any assigned Angle, suppose A; then, your Instrument being planted at A, direct the Index to the next Station at B, and the South End of the Needle will point at 207 Degrees in the *Circumferentor*. And for the following Angles and Bearing, when the Instru-

ment is planted at $\left. \begin{matrix} B \\ C \\ D \\ E \\ F \\ G \end{matrix} \right\}$ direct the fix'd Sights to $\left. \begin{matrix} A \\ B \\ C \\ D \\ E \\ F \end{matrix} \right\}$

and there screw the Instrument fast, and then direct the Index to $\left. \begin{matrix} C \\ D \\ E \\ F \\ G \\ A \end{matrix} \right\}$

and the End of the Index next your Eye will cut on the Limb the Angles $\left. \begin{matrix} 84. & 00 \\ 113. & 30 \\ 237. & 45 \\ 49. & 55 \\ 102. & 40 \\ 234. & 00 \end{matrix} \right\}$

and the South End of the Needle will, as in the *Circumferentor*, point at $\left. \begin{matrix} 111. & 00 \\ 44. & 30 \\ 102. & 15 \\ 331. & 50 \\ 254. & 30 \\ 308. & 30 \end{matrix} \right\}$

And

And with a *Theodolite*, that hath the Box fix'd to the Index, and the Numbers of the Plate contrary to those of the Box, while the Eye is conceived placed in the Center, increase from the Right to the Left, and so most proper to work according to the Sun's Motion; if you would take the Angles and the Bearings of the Lines, of Fig. 12. and begin from any assigned Angle, suppose A; then your Instrument being planted at A, direct the Index to the next Station G, and the South End of the Needle will point at $231^{\circ} 30'$ in the *Circumferentor*. And for all the following Angles and Bearings, when the

Instrument is planted at	{	G	direct the fixed Sights to	{	A
		F			G
		E			F
		D			E
		C			D
		B			C

and there screw the Instrument fast, and then direct the Index to	{	F
		E
		D
		C
		B
		A

and the End of the Index next the Eye will cut on the Limb the Angle	{	234. 00
		102. 40
		49. 35
		237. 45
		113. 30
		84. 00

and the South End of the Needle, as in the <i>Circumferentor</i> , will point at the bearing	{	285. 30
		208. 10
		77. 45
		135. 30
		69. 00
		333. 00

But with a *Theodolite* that hath the Box fixed to the Plate, and the Numbers on the Plate as well as those

So, with a *Theodolite* that hath the Box fix'd to the Index, and the Numbers on the Plate, while the Eye is conceived placed in the Center, increase from the Left to the Right, but those in the Box the contrary way, and so most proper to work against the Sun: If you would take the Bearings of the Lines of *Fig. 12.* and if you would begin from any assigned Angle, suppose A; then, your Instrument being planted at A, direct the Index to the next Station at B, and the South End of the Needle will point at 207 Degrees in the *Circumferentor*. And for the following Angles and Bearing, when the Instru-

ment is planted at $\left\{ \begin{array}{c} B \\ C \\ D \\ E \\ F \\ G \end{array} \right\}$ direct the fix'd Sights to $\left\{ \begin{array}{c} A \\ B \\ C \\ D \\ E \\ F \end{array} \right\}$

and there screw the Instrument fast, and then direct the Index to $\left\{ \begin{array}{c} C \\ D \\ E \\ F \\ G \\ A \end{array} \right\}$

and the End of the Index next your Eye will cut on the Limb the Angles $\left\{ \begin{array}{cc} 84. & 00 \\ 113. & 30 \\ 237. & 45 \\ 49. & 55 \\ 102. & 40 \\ 234. & 00 \end{array} \right\}$

and the South End of the Needle will, as in the *Circumferentor*, point at $\left\{ \begin{array}{cc} 111. & 00 \\ 44. & 30 \\ 102. & 15 \\ 331. & 50 \\ 254. & 30 \\ 308. & 30 \end{array} \right\}$

And

And with a *Theodolite*, that hath the Box fix'd to the Index, and the Numbers of the Plate contrary to those of the Box, while the Eye is conceived placed in the Center, increase from the Right to the Left, and so most proper to work according to the Sun's Motion; if you would take the Angles and the Bearings of the Lines, of Fig. 12. and begin from any assigned Angle, suppose A; then your Instrument being planted at A, direct the Index to the next Station G, and the South End of the Needle will point at $231^{\circ} 30'$ in the *Circumferentor*. And for all the following Angles and Bearings, when the

Instrument is planted at $\left. \begin{matrix} G \\ F \\ E \\ D \\ C \\ B \end{matrix} \right\}$ direct the fixed Sights to $\left. \begin{matrix} A \\ G \\ F \\ E \\ D \\ C \end{matrix} \right\}$

and there screw the Instrument fast, and then direct the Index to $\left. \begin{matrix} F \\ E \\ D \\ C \\ B \\ A \end{matrix} \right\}$

and the End of the Index next the Eye will cut on the Limb the Angle

$\left. \begin{matrix} 234. 00 \\ 102. 40 \\ 49. 35 \\ 237. 45 \\ 113. 30 \\ 84. 00 \end{matrix} \right\}$

and the South End of the Needle, as in the *Circumferentor*, will point at the bearing

$\left. \begin{matrix} 285. 30 \\ 208. 10 \\ 77. 45 \\ 135. 30 \\ 69. 00 \\ 333. 00 \end{matrix} \right\}$

But with a *Theodolite* that hath the Box fixed to the Plate, and the Numbers on the Plate as well as those

those in the Box (the Eye being placed in the Center) increase from the Right to the Left; and therefore most proper to work contrary to the Sun's Motion; if you would take the Angles and the Bearings of the Lines of Fig. 12. and begin at an assigned Angle A; then your Instrument being planted at A, direct the fixed Sights to B, and the South End of the Needle will point at $207^{\circ} 00'$, as in the *Circumferentor*, and as in the first Example. And for all the following Angles and Bearings, when the Instru-

ment is planted at $\left\{ \begin{matrix} B \\ C \\ D \\ E \\ F \\ G \end{matrix} \right\}$ direct the fixed Sights to $\left\{ \begin{matrix} C \\ D \\ E \\ F \\ G \\ A \end{matrix} \right\}$

then screw the Instrument fast, and direct the Index to $\left\{ \begin{matrix} A \\ B \\ C \\ D \\ E \\ F \end{matrix} \right\}$

so will the End of the Index next the Eye cut on the Limb, the Angle $\left\{ \begin{matrix} 84. & 00 \\ 113. & 30 \\ 237. & 45 \\ 49. & 35 \\ 102. & 40 \\ 234. & 00 \end{matrix} \right\}$

and the South End of the Needle, as in the *Circumferentor*, will point at the Bearings $\left\{ \begin{matrix} 111. & 00 \\ 44. & 30 \\ 102. & 15 \\ 331. & 50 \\ 254. & 30 \\ 308. & 30 \end{matrix} \right\}$

both as in the first Example.

Also with a *Theodolite*, that hath the Box fixed to the Plate, and the Numbers on the Plate, as well as those in the Box, the Eye placed in the Center; increase from the Left to the Right, and therefore most proper

proper to work according to the Sun's Motion ; if you would take the Angles and the Bearings of the Lines Fig. 12. and begin at an assigned Angle at A, direct the fixed Sights to G, and the South End of the Needle will point at $231^{\circ} 30'$ as in the second Example. And for all the following Angles and Bear-

ings when the Instrument is planted at $\left. \begin{matrix} G \\ F \\ E \\ D \\ C \\ B \end{matrix} \right\}$ direct the fixed Sights to $\left. \begin{matrix} F \\ E \\ D \\ C \\ B \\ A \end{matrix} \right\}$

then screw the Index fast, and direct the Index to $\left. \begin{matrix} A \\ G \\ F \\ E \\ D \\ C \end{matrix} \right\}$

and so will the End of the Index next the Eye cut on the Limb the Angle $\left. \begin{matrix} 234. & 00 \\ 102. & 40 \\ 49. & 35 \\ 237. & 45 \\ 113. & 30 \\ 84. & 00 \end{matrix} \right\}$

and the South End of the Needle, as in the *Circumferentor*, will point at the Bearings $\left. \begin{matrix} 285. & 30 \\ 208. & 10 \\ 77. & 45 \\ 135. & 30 \\ 69. & 00 \\ 333. & 00 \end{matrix} \right\}$

both as in the second Example.

With either of these Four Instruments, the Angles and the Bearings of the Lines are taken, at once setting the Index, as easily and expeditiously as the Angle it self only ; which evidently appears from the Four preceding Examples. And the Truth of these Observations may be readily proved by either of the Rules already laid down.

For, the Instrument being planted at B, in the First and Third Examples, if to $111^{\circ} 00'$ the Bearing

ing there taken, you add $180^{\circ} 00'$ and from the Sum $291^{\circ} 00'$, take the last Bearing $207^{\circ} 00'$, there will remain $84^{\circ} 00'$, which gives the Angle taken at B, exactly as there observed; and proves the Angle and these Two Bearings to have been truly observed.

In like manner, the Instrument being planted at C, in the same Examples; if to the Bearing there taken, $44^{\circ} 30'$, you add $180^{\circ} 00'$, and from the Sum $224^{\circ} 30'$, you subtract $111^{\circ} 00'$, the Bearing taken at the last Station; the Remainder $113^{\circ} 30'$ gives the Angle at C exactly as it was there observed; which proves that the Angle, and also the last and present Bearings are truly observed.

Also the Instrument being planted at D; if to the Bearing there taken $102^{\circ} 15'$, you add $180^{\circ} 00'$, and from the Sum $282^{\circ} 15'$, take $44^{\circ} 30'$ the last Bearing; the Remainder $237^{\circ} 45'$ gives the Angle at D, as there observed.

But the Instrument being planted at E; if to the Bearing there taken, $331^{\circ} 50'$, you add $180^{\circ} 00'$, and from the Sum $511^{\circ} 50'$, you subtract $102^{\circ} 15'$, the last Bearing; the Remainder $409^{\circ} 35'$ lessened by 360° , because greater than 360 , gives $49^{\circ} 35'$, the Angle at E. And so of all the rest.

And in like manner may the Angles and Bearings be compared in the second and fourth Examples.

Or the Angles and Bearings may be compared by the second Rule thus. The Instrument being planted at B, if to $84^{\circ} 00'$, the present Angle, you add $207^{\circ} 00'$, the last Bearing, and from the Sum $291^{\circ} 00'$, you take $180^{\circ} 00'$, the Remainder $111^{\circ} 00'$, gives the present Bearing, as observed.

The Angles and Bearings being truly taken, it remains to shew how

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To Plott, and therein to discover and correct
an Error before it is communicated to the
following Part of the Work.

HAVING provided yourself with a *Protractor*,
whose Numbers increase contrary to those in
the Box, draw all over your designed Draught pa-
rallel Lines, as in plotting Observations taken with
the *Circumferentor*.

Then from some Point convenient to represent your
first Station, as in the { first and third } Examples
from A, lay down by the Bearing { 207° 00' }
the first Line { A B } as taught in plotting Obser-
vations taken with the *Circumferentor*.

Then on the Point { B } lay the Centre of the
Protractor, and its Diameter on the Line { A B } pro-
duced both ways, if need require, so that the Begin-
ning of the Degrees may be towards the last Station
if the Angle be less than 180 Degrees, but the con-
trary way if greater; then at the Edge of the *Pro-
tractor* make a Mark against { 84° 00' } the De-
grees of the Angle { B } and draw the Line { B C }
Now turn the *Protractor* about on its Center, till its
Diameter be parallel to the Meridians, so that the
Beginning of the Degrees be towards the North,
when the Bearing is less than 180, but contrarily
when more; and then if the Line { B C } cut the

Bearing { 111° 00' } on the Edge of the *Pro-
tractor*,
D 2

tractor, that Line is truly laid down: Otherwise not.

In like manner, may any other Angles be examined, and if found erroneous, the Error may be corrected, before it is communicated to the following Part of the Work.

And we may observe, that, if the Plot be laid down by the Bearings of the Lines, those Bearings may be examined by measuring the Angles as soon as plotted.

Though this Method sufficiently recommends it self, both in respect of Dispatch as well as ACCURACY; I do not expect it will be practised by any but the Unprejudiced. For He, who hath surveyed much Land with a *Circumferentor* alone, or with a *Semicircle* or *Theodolite*, without a Needle, or with any other Instrument, that doth not afford a double Observation; He, I say, hath not provided a Check to his Frailty, and will scarce forsake his old Way, because he will not accuse himself.

There are two other ways to use these *Theodolites*, each equally exact with the former, but not so expeditious. One way is to take the Bearing with the traversing Quadrants; the other is to take the Bearing with the Degrees on the Limb. But the Angle is always taken as above.

If you would use the traversing Quadrants, then the observing, the plotting, and the Proof in plotting, are all as easily, speedily, and exactly done as by the first Method; but the Proof of the Observation in the Field, though equally true with the former, is neither so easily performed, nor so easily reduced to one single Rule. But the Person who is resolved to plot by the traversing Quadrants, had best take the Observation both by the *Quadrants* and by the *Circumferentor*; and then prove the Observation in the Field by the *Circumferentor*, and the Plotting by the traversing Quadrants.

Lastly, If you would take the Direction by the Divisions on the Limb with a *Theodolite*, whose Box is fixed to the Plate, then (after you have taken the

Angle,

Angle, as before taught) turn the Instrument about till the North End of the Needle point at 360 Degrees in the Box, and screw it fast; now direct the Index to the next Station, and the End next you will give on the Limb the Direction in Degrees and Minutes, as in the former Examples.

But with a *Theodolite*, whose Box is fix'd to the Index, if you would take the Direction by the Divisions on the Limb; then (after you have taken the Angle, as before taught) direct the fix'd Sights to the next Station, and screw the Instrument fast, and turn the Index about till the North End of the Needle point exactly at 360 Degrees in the Box; and then will the End of the Index nearest to the South End of the Needle cut on the Limb the Direction in Degrees and Minutes. But the *Protractor* to lay this Bearing down, must be numbred contrary to the Limb on the Instrument.

The great Advantage usually proposed by this last Method, is, that the Degrees on the Limb are larger and more distinctly cut, and consequently more nearly estimated than those in the Box. But consider, that you can no better bring the Needle to point at any one Degree, than you can estimate its Position in any other Degree; and that since we use the Needle, all the Objections made in one Method are incident to the other; and then you may easily conclude, that the Advantage is only imaginary.

Besides, here we are obliged to take two Observations, either of which take up as much Time as the one Observation used in the former Method; which renders it not so fit for a Practitioner.

Of the Use of these *Theodolites*, I have one Thing more to advertise, *viz.* To measure and cast up the Content of one large single Wood or Common, where there are some scores of Angles to be taken; the safest Way is to cast, without plotting, by Help of the Needle. And in this Case I would take the Directions both with the *Circumferentor* and the *traversing Quadrants*; and in the Field prove the Directions taken with the *Circumferentor* by the Angles

gles taken by the Limb; and then, still in the Field, prove both Lengths and Directions, in calculating a Traverse, by help of a Traverse Table; and lastly, from this Traverse (at leisure) deduce the true Content.

But the Traverse Tables that are now extant, are but Specimens of those which are fit for Use; Instruments are not sufficiently exact, and Trigonometrical Operations too laborious, and therefore I must defer this way of Computation, till some Person who hath Leisure and Patience to serve the World, in calculating such a Table, is resolved to do it; If I can procure it, as indeed I have some Hopes thereof, it may be published with its Uses in Practical Surveying and Navigation in a Pocket Volume.

Of any one of the four *Theodolites*, which have the Numbers in the Box contrary to those *Theodolites* before described, one or more Inconvenience will always arise, use which of the three forementioned Methods you please.

It is true, the Angle taken by the Limb is perform'd as taught in the preceding Rules; but since it is not safe to work by the Limb only, if you use the *Circumferentor*, as taught in the first Rule, you must either subtract the Direction from 360 Degrees, and enter the Remainder instead of the Direction pointed at by the Needle; or else use two *Protractors*, which will be troublesome, and also apt to cause Mistakes by using the one for the other.

If you use the *traversing Quadrants* only, then indeed the Use is in all respects the same with the preceding ones; but these, as I have already shewn, are not so expeditious as, nor more exact than, the Method first laid down.

If you will take the Direction by the Limb, and still make one *Protractor* plot both Observations, you must direct your Instrument twice, whereas by the first Method laid down, it might be done at once.

Lastly,

Lastly, of *Theodolites* those are best which have Telescopes with plain Sights on them, and so contrived that the Surveyor may at any time adjust any small Accident, without coming to a Workman, and that both of them may be elevated or depressed at least ten Degrees; one of these Telescopes instead of the fix'd Sights, the other instead of the moveable ones, and as long a Needle as will play well, with other the like Conveniencies, sufficiently known to a skilful Instrument-maker.

To Observe with a Semicircle that hath a Box and Needle.

A Semicircle is just half the *Theodolite*, and admits of just as many Varieties; it is numbred on the Limb to 180 Degrees, and in an Arch concentrick to this is numbred under 10, 20, 30, &c. with the Numbers 190, 200, 210, &c. to 360. Its Use, in all respects (both to the Plate and Box) is the same with the *Theodolite*; save in this, that when the End of the Index falls off the Plate, the Degrees cut on the Limb are to be taken from the further Part of the Index from the Degrees of the inner Circle, and will be always more than 180 Degrees.

There are some other Manners of numbering and dividing (and perhaps without a Box and Needle) used in these Instruments; but they are not worth Notice.

The Peractor,

IS part only of that *Theodolite*, whose Box is fix'd to the Plate; and the Directions for the *Theodolite* will serve for this.

The

*The Divisions on the Limb of the Plain Table,
with its Box and Needle.*

Like that of the *Theodolite*, or *Modern Circumferenter*; if the 360 Degrees of the Limb be upwards, and the Box and Needle screwed to the Side of the Table; it performs, in all respects, the Use of the *Theodolite*, whose Box is fix'd to the Plate. For lay the Edge of the Index on the Division numbered 360, to that numbered 180; and turn the whole Instrument about, till through the Sights you see the next Station (the 360 being towards you, as taught in the *Theodolite*) and there screw it fast; then turn the Index about upon the Centre, till you see your last Station, and so will the End of the Index next you, cut the Degrees of the Angle, and the South End of the Needle will give the Direction.

But if the Box be screwed to the Index, it in like manner becomes a *Theodolite*, with a Box fix'd to the Index.

If the Box and Needle be screwed to the Staff, it is a *Circumferenter*.

If the Box be screwed to the Table, and that side of the Frame be upwards, which is divided into four Nineties, it is the *Perambulator*.

If that side of the Frame is upwards, which hath only the 180 Degrees of the Semicircle numbred on it, then it is a Semicircle, either with the Box to the Plate or not, according as the Box is fix'd to the Table or the Index.

And what hath been already said of these Instruments may serve for Directions, to use the plain Table these several Ways, and need not be again repeated here.

And hence it seems that the Plain Table might properly be called *Panorganon*, in respect of Land-Surveying.

Indeed,

Indeed, if instead of the small Holes for Centers to be used with a Protracting-pin by the Fiducial Edge of the Index, there were Conick Holes through the Tables; and also a Hole, being the next adjoining great Segment of the same Cone made in the Index to screw it to the Centers by a Conical Pin at the End of it; and the Fiducial Edge of the extreame Parts was filed away, so that when continued, they would pass thro' this Central Pin; and if the Divisions on the Frame be cut as well as on the Limb of the *Theodolite*; and if also the Wood would neither shrink nor swell any more than Brass; and a Telescope mounted on the Sights; and the Back side of the Index brought also to a Fiducial Edge; then I should think it a very compleat Instrument.

It remains to shew, how to take Angles when we use the plain Table covered with a Sheet of Paper; but this hath been sufficiently handled by Mr. *Leybourn* and others; therefore I shall content my self with laying down a Method to correct an Error committed before it is communicated to the following Parts of the Work. Though I do not any ways doubt but the Reader may, by what follows, learn the Use of this plain Instrument.

Suppose you were to draw the Plan of the Field A L M N O P Q R; (Fig 13.) draw on the Table a Line to represent A L in the Field, and by your Scale lay down on the Plan the Distance you found A L in the Field to be, when you measured it with a Chain. Then planting your Table at L, lay the Index on A L, and turn the whole Instrument about till you see A, and then screw it fast, then turn the Index about on L, till through the Sights you see M, and draw L M; and by your Scale give it on the Table the same Length you found it to have in the Field, by measuring with your Chain.

Now in order to examine the Length of L M, and also its Position in respect of A L; plant your Instrument at M, lay the Index at L M, and by turning the Instrument, direct the Sights to L, and
E
there

there screw it fast; then direct the Index turn'd about on M, towards A in the Field, and if the Edge doth not cut the Point A in the Table, the Line L M is false, either in Position or Length, and therefore must be examined and corrected before you proceed.

The Line L M being truly laid down, plant the Instrument at M, and lay the Index on L M, and direct the Sights to L, by turning round the whole Instrument, and then screw the Instrument fast: Now turn the Index about on M, till through the Sights you see the Hair cut N, and by the Edge of the Index draw a strait Line; and by your Scale, from N, lay the Length N M equal to what you measured it in the Field.

But to prove whether the Line N M is truly laid down both in Position and Length; having planted the Instrument at N, and directed the Index on N M to M, and there screwed the Instrument fast; from N direct the Index to either of the Marks L or A in the Field; and if the Index then doth not accordingly cut L or A on the Table, the Line M N is false, and must be corrected before you proceed.

And in like Manner through the whole Survey, you may proceed to lay down every Line, and examine it before you leave it, provided that you leave your Marks all standing at every Station, by laying the Index on the last Line, and turning the Instrument about till thro' the Sights you see the Hair cut the last Mark; and then screwing the Instrument fast; if you turn the Index about on the Point representing the Station where the Instrument stands, till you see any one of the Marks passed by, except the last of all; and if the Edge of the Index doth not cut on the Table, the Representative of that Point, the last Line is not truly laid down.

But when you are at any Mark, suppose N, if you cannot see any other Mark but M, set up some Mark a, from whence you may see some of the preceding Marks, suppose L, as well as M and N; and

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and from this Point *a* examine the Truth of the Position of the Line *M N*.

Or thus; You may set up a Mark *a*, any where in the Field, from whence all, or several of the Angles may be seen; then the Instrument being at *A*, and the Index on *A L*, screw the Instrument fast; and turn the Instrument on *A*, till you see *a*, and draw *A a*.

The Instrument being at *L*, the Index on *L A*, and the Index directed to *A*; let the Instrument be screwed fast; turn the Index about on *L*, till through the Sights you see *a*, draw by the Edge of the Index *L a*; and so will the Point *a* be determined.

Then the Instrument being at *M*, the Index on *L M*, and the Sights directed to *L*, and then the Instrument screwed fast, turn the Index about on *M*, till through the Sights you see the Mark *a* in the Field: Then if the Edge of the Index doth not cut *a* in the Table; the Line *L M* is false either in Position or Length.

In like Manner the Table being at *N*, the Index on *N M*, and the Sights directed to *M*, and then the Instrument screwed fast, turn the Index about on *N*, and direct the Sights to the Mark *a*; and if the Edge of the Index doth not cut *a*, on the Table; then *M N* is false either in Position or Length.

Lastly, instead of a Mark set up as *a*, you may use any remarkable Tree, Steeple, &c. not at too great a Distance from you, whether it be in the Land you are then Surveying, or not.

And when the Mark you have last used is at too great a Distance from you, or lies almost in the same strait Line with that which you are about to lay down; then use some other Mark in its Stead.

Angles may be taken with Rods of Five and Ten Foot, or Off-set Staves.

ANGLES taken with Rods, are usually about Gardens and Buildings, but are no ways fitting for large Plans.

As for the Chain, a *Surveyor* may with it, for a Shift, perform many Works, but not all ; and this, at best, is both laborious and tedious.

The best Instruments for Surveying all Manner of Lands, both great and small, in all Cases, are the *Theodolites* before mentioned.

If the *Surveyor* have only a Chain, and hath drawn his Plane, and would draw thereon a Meridian Line ; he may do it thus ; Exactly at 12 a Clock, mark the Shadow of some upright Object, as the Corner of a House, or some strait Tree, or your Staff set upright ; then plot this Line on your Plane, and it is a Meridian Line.

Or thus ; In a Night when the *Pole Star* is to be seen, place your self so, that your Eye, the *Pole-Star* and some upright Object, as the Corner of a House or straight Tree, be in one straight Line ; then plot the Line from your Feet to the upright Object, and it will be a Meridian-line.

Indeed the *Pole Star* moves round the real Pole ; but at so small a Distance from it, that in this Case the Variation may be rejected.

However, you	$\left\{ \begin{array}{l} \text{March and September at 12} \\ \text{April and October at 2} \\ \text{May and November at 4} \\ \text{June and December at 6} \\ \text{July and January at 8} \\ \text{August and February at 10} \end{array} \right\}$
may observe that the	
<i>Pole Star</i> is full	
North about the	
20th Day of	

a Clock either Morning or Evening ; always encreasing nearly two Hours for every Month.

Therefore, if the Observation is made about these Times, the Variation will be very inconsiderable.

Also observe, That 5, 6, or 7 Hours before or after these Times, if the Pointers are to $\left\{ \begin{array}{l} \text{Eastward} \\ \text{Westward} \end{array} \right\}$ of the Pole ; then the Variation by the Star is about 3 Degrees and a Half $\left\{ \begin{array}{l} \text{Westward} \\ \text{Eastward} \end{array} \right\}$ and this Variation is the greatest.



S E C T. III.

Of the CHAIN.

FIRST, provide a Staff just 6 Foot 7 Inches and two Tenths long, which divide into 10 equal Parts; and so will the whole be the Length of 10 Links, and each Part the Length of one, and 10 Times the Length of this Staff the Length of the whole Chain.

With this Staff examine the Length of the Chain, and also of every 10 Links; stretching it on level Ground, to such a Degree as you design to stretch it, when you measure with it.

Before you measure with it, provide 9 Arrows or small Sticks, each about Two Foot long, and Two strait Staves about 5 Foot long each.

When you are about to measure with it, let him that leads the Chain take the 9 Arrows and one of the Staves; and he that follows it, the other Staff.

Then the Follower standing at the Station, let him direct the Leader to place his 5 Foot Staff at the Chain's End in the same right Line with the Stations; and then let the Leader take up the Staff, and in its Place sticking down one of the Arrows, go on.

Now the Follower being come to the Arrow, let him direct the Leader to place his Staff as before.

And then let the Leader, standing at his Staff, look back towards the last Station, and he will see the Staves and the Station in one right Line, if they have directed right. But if they are not in one right Line, the Leader must direct the Follower to place his Staff at the Chain's End, in the same right Line with the Station, and the Leader's Staff.

And so, let each direct the other, till the two Staves and the two Stations are in one right Line; and then

then must the Leader put down an Arrow in the place of his Staff, and go on: And the Follower take up the Arrow where he last stood, and go after him.

And let him thus proceed till they have measured to the Station, or till the Leader is nearer the Station than one Chain's Length; and then will the Number of the whole Chains measured, be expressed by the Number of the Arrows prick'd down, which suppose 8.

Now let the Leader go on to the Station, and there hold the End of the Chain, and let the Follower stretch the Chain as usual, and then see, how many Links are contained between the last Arrow and the Station; which may be readily counted by help of different Bits of Brass, or Curtain Rings, or other Marks fix'd at the End of every tenth Link, which Links suppose to be 47.

Lastly, Enter in your Field-book the Chains and Links without any Distinction between them, and they will be 847; which imply either 847 Links, or 8 Chains 47 Links.

But here we are to observe, that the Links must always possess two Places; as 8 Chains and 4 Links must be written 804; that is 8 Chains and 4 Links, 804 Links, and 8 Chains without any Links, must be written 800, implying 8 Chains, or 800 Links.

It is necessary that the *Surveyor* should enquire of his Assistants at the End of every measured Length, how many Arrows each hath; and if the Sum of the Arrows are not Nine, it is evident they have dropt, or left behind, those that are wanting; and consequently the last Length measured is doubtful, and must be re-measured before you proceed.

When you are come to the Station, if it be convenient to continue the Length, let the Follower stand Chain, and so place his Staff, that it and the two at the last Arrow, and let the Leader go on with the Stations are in one right Line; then in the Place of the Staff put down an Arrow, and go on; always directing himself to place his Staff, and consequently his Arrow, by the two Stations,

When

When you have continued your Length, till you have nearly lost Sight in the farthest Station, set up another Station-staff in the Place of the last Arrow, and go on to continue by the two nearest Stations.

But withal take this Caution, That it is not safe to continue Lengths very long, when the Stations are near one another.

Lastly, When your Length is very great, having measured nine Chains, let the Leader go on and set his Staff down at the Tenth ; now let the Follower put his Staff in the Place of the Leader's, and give the Leader the nine Arrows, and then go on. But observe to enter in your Field-book these ten Chains, and never trust to your Memory. And if your Length consists of ten Chains more, work as before, and enter 20 Chains, and so on.



S E C T. IV.

To Cast up the CONTENTS of LAND.

THE Contents of any Field may be readily cast up thus : Take every Base and every Perpendicular of every Triangle, and every Diagonal of every *Trapezia*, in Links, esteeming every Chain one 100 ; in every *Trapezium*, multiply the Sum of the Perpendiculars by the Diagonal ; and in every single Triangle, the Base by the Perpendicular ; then add the several Products together : Then from the Right Hand make a Dash between the fourth and fifth Places, and another between the fifth and sixth ; then halve the Figures to the Left Hand of the Dashes, and so will this half be Acres. If an Unite remain, that Unite is an half Acre or two Roods ;
and

and if the Figure between the Dashes be five or more, take five from it, and account it another Rood: Lastly, Multiply the remaining Figure o between the Dashes by 8, and to the Product add the Tens to be carried from the Fourth Figure, and you have the Perches. If any Person is so curious, as to esteem the Decimal Parts of the Perches, they will be the Product made by multiplying the Figures to the Right-hand of the Dash by 8. So in Figure 14 the Operation will be thus.

$$\begin{array}{r}
 313 \text{ --- } A C \quad 214 \text{ --- } K L \quad F G \text{ --- } 418 \\
 612 \text{ --- } D E \quad 396 \text{ --- } H I \quad A H \text{ --- } 900 \\
 \hline
 925 \quad \quad \quad 610 \quad \quad \quad 376200 \\
 725 \text{ --- } B F \quad 500 \text{ --- } F M \\
 \hline
 4625 \quad \quad \quad 305000 \\
 1850 \\
 6475 \\
 \hline
 670625
 \end{array}$$

$$\begin{array}{r}
 670625 \\
 305000 \\
 \hline
 376200 \\
 \hline
 13 \overline{) 51825} \\
 A. R. P. \\
 \text{Answer, } 6 . 3 . 1
 \end{array}$$

Here half 13 gives 6 the Acres, and one remaining is 2 Roods; then the 5 between the Dashes gives another Rood; and so the whole is 6 Acres and 3 Roods; and because there is but one Ten to be carried from the fourth Place, and that after the 5 is taken out of the fifth, there remains nothing, there is but one Perch.

In like Manner if the whole Sum of all the

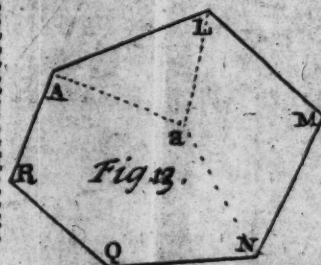
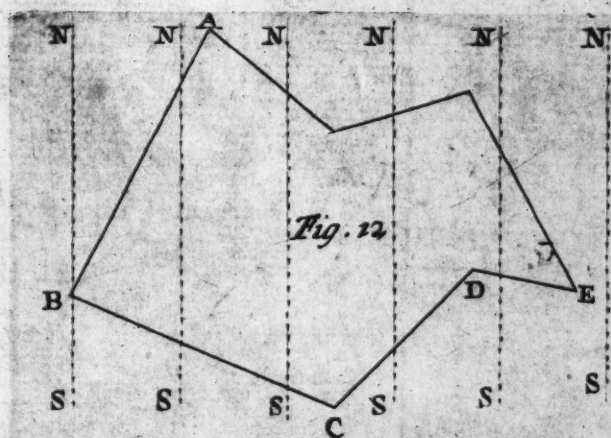
$$\begin{array}{l}
 \text{Products be } \left\{ \begin{array}{l} 17 \overline{) 45364} \\ 11 \overline{) 92765} \\ 10 \overline{) 54321} \\ 8 \overline{) 43764} \end{array} \right\} \text{ the Content is } \left\{ \begin{array}{l} A. R. P. \\ 8 . 2 . 36 \\ 5 . 3 . 34 \\ 5 . 1 . 03 \\ 4 . 0 . 35 \\ \hline 80 \end{array} \right.
 \end{array}$$

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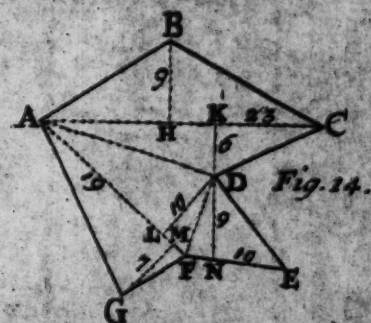
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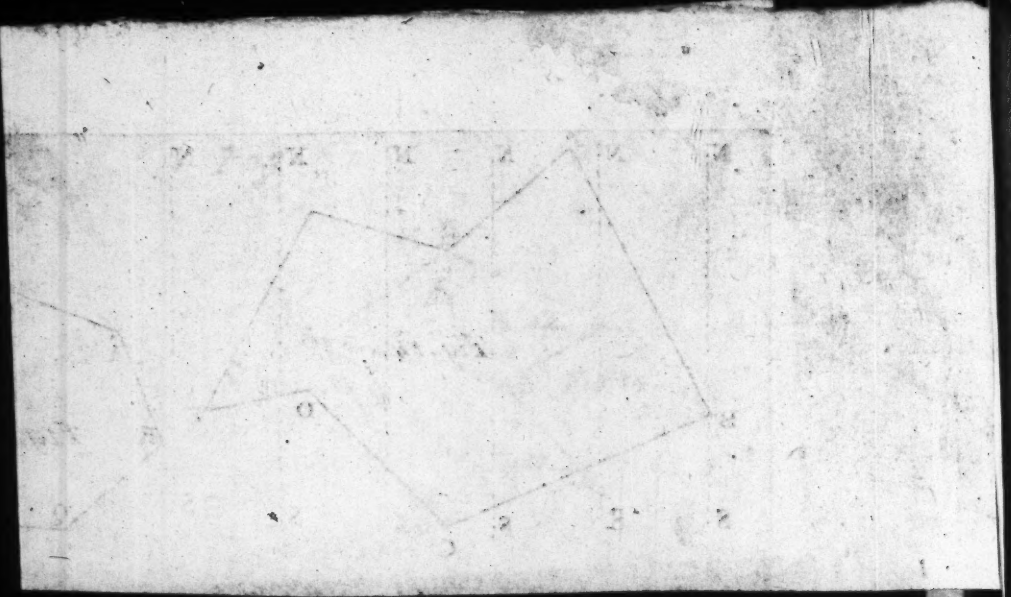
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So if the Sum of the Products be 4176354 . the Content is $20 \cdot 3 \cdot 210832$. But this Method must be only used when the Figure is reduced to Triangles and Trapezias.



S E C T. V.

Of the Laying out of Lands.

WHEN any Number of Acres, Roods and Perches are to be laid out, it is convenient to reduce them to square Links; which may be done thus :

If the Roods are $\left. \begin{matrix} 1 \\ 2 \\ 3 \end{matrix} \right\}$ add $\left. \begin{matrix} 40 \\ 80 \\ 120 \end{matrix} \right\}$ to the Perches, and to the Sum annex 4 Cyphers. Divide this last by 16, and write the Quotient Figures, if they be 5, after the Acres.

But when the Quotient Figures are but $\left. \begin{matrix} 4 \\ 3 \end{matrix} \right\}$ write one Cypher after the Acres; and then the Quotient Figures; and so will you have the square Links required.

Ex. I. Reduce $\begin{matrix} A. & R. & P. \\ 7 & 2 & 24 \end{matrix}$ to square Links.

$$\begin{array}{r} 24 \\ 80 \\ \hline 16)1040000(65000 \\ 80000 \end{array}$$

Answer 765000

Ex. II.

A. R. P.

Ex. II. Reduce 7 0 11 to square Links.

16)110000(6875

146

120

80

Answer 706875

A. R. P.

Ex. III. Reduce 7 0 01 to square Links.

16)10000(625

40

80

Answer 700625

The Problems of laying out Lands, as met with in Practice, are in Number 3.

For, either the Partition line is required to be parallel to some other Line assigned, or to pass through a Point assigned in the Fence, or to pass through some Point assigned within the Land.

In the Solution of each of these, I chuse an Arithmetical Approximation rather than a Geometrical Construction; for Reasons sufficiently known to those who have practised.

P R O B. I.

Let it be required to cut off towards A B, Fig. 14, 8 Acres, 3 Rods 18 Perches, by a Line drawn parallel to A B.

FIRST, Draw parallel to A B a Line C D by guess, and then cast up the Content of the Figure C D H G, which suppose to be 772575 square Links,

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Links, which is less than $8\ 3\ 18$, or 886250 square Links, by 113675 square Links, which shews, that the Partition-line is more towards K.

Now divide the Excess 113675 , by 965 , the Length of CD in Links, and at the Distance of 118 Links the Quotient, draw EF parallel to CD , and it will be sufficiently near the Partition-line required.

But if by Curiosity you are led to correct the Variation, you may conceive CD to be a Line given in Position, and 113675 square Links, to be the Quantity to be cut off, and EF the Line drawn by guess.

But if the Line CD had cut of the Quantity $CDHG$ greater than that required, then the Partition-line had been more towards GH , whose Distance from CD , would be found as before, by dividing the Difference by the Length CD .

P R O B. II.

A. R. P.

To cut off $5\ 0\ 35$ towards L , Fig. 15. by a Line drawn from the Point V .

A. R. P.

REduce the given Quantity $5\ 0\ 35$ to square Links, and they will be 521875 .

Then draw LV , forming the Triangle VLW , which being cast up amounts to 3800 square Links, which is too little.

To the next Angle draw VM , forming the Triangle VLM , which being cast up will be found to amount to 297632 square Links, which added to the Triangle VLW , you have 328432 square Links, the Content of the Trapezium $VWLM$, which is still too little.

To the next Angle draw VP forming another Triangle, whose Content 403850 square Links added to

F 2

328432

328432, the Content of the preceding Figure, gives 732282 square Links, which is more than the required Quantity by 210407 square Links; therefore the Partition-line passes between P and M. Divide the Excess by 497, half the Length of V O the Perpendicular in Links, and lay 423 the Quotient from P to N, and so shall V N be the true Line of Partition.

P R O B. III.

A. R. P.

To cut off 7 3 13 towards B from a Line passing by the Point A. See Fig. 16.

IT may be thus performed: Consider through which two Sides the Partition-line will pass. Reduce the Figure to a *Trapezium*, still retaining those Sides, as taught in the following Page: Which divide by a Line through the assigned Point A.

But, because this Method is tedious, and depends on the Concourse of many Lines; and though we should use Numbers, we should little mend the Matter, and indeed is often impossible to be perform'd by one single Line, it may not be amiss to shew how to do it by two Lines.

From A to any two Angles H and B, draw the Lines A H, A B, forming the Triangle A H B, which being cast up amounts to 338000 square Links less than the Quantity required.

To the next Angle C draw A C forming the Triangle A B C, which being cast up, amounts to 322500 square Links, which added to the Triangle A H B gives 660500 square Links, which are still less than the Quantity required.

To the next Angle F draw A F, forming the Triangle A C F, whose Content 280800 square Links added to the preceding Triangles A H B A B C gives 941300, which exceeds the Quantity required by 158175 square Links; now divide this Excess

158175

158175 by 292, half the Length of the Perpendicular EL , and lay the Quotient 541 from F to D , and draw AD , and so will the Lines HA , AD be the Partition required.

It may not be improper, perhaps to add in this Place, the Manner of casting up such Fields as consist of many small Breaks in the Hedges; without reducing them to a multitude of Triangles, *e. g.*

Let *Fig. 17.* be such a Field, produce NM , some one of the longest Sides; then lay the Edge of a strait Ruler from M , one of the Angles at the End of NM , to G the next but one; holding the Ruler thus fast, take with a Pair of Compasses the Distance from L to the Edge of the Ruler, and with this Distance let one Point of the Compasses move gently close to the Ruler, while the other Point traces out a Line parallel to it, and crosses NM in Q . Now draw GQ , and it will reduce that Side of the Figure, which was bounded by the two Lines ML , LG , to another bounded by GQ , one single Line only.

In like Manner QG being produced, and a Ruler laid from G to E , carry the Distance of F from the Ruler parallel to it, till you cross MG in K . Secondly, Lay a Ruler from K to the next Point D , and carry the Distance of E , the last Point $\odot$, from the Ruler parallel to it, till you cross MG in H . Thirdly, Lay a Ruler from H to the next Point C , and carry the Distance of D , the last Point from it, parallel, till you cross MG in I . Lastly, Draw IC , and the Side GC which consisted of the four Lines GF , FE , ED , DC , will be reduced to the Side IC , consisting of one Line only. And in like manner we might proceed if the Lines were never so many.

And thus laying a Ruler from CP draw PO ; and in like manner AQ . So will the ten-sided Figure be reduced to a four-sided one, and so then may be cast up by one Multiplication only.

Provide a Plate of thin Brass in form of an Arch of a Circle; near whole Ends let there be drilled
small

small Holes, through which string it with a very fine Hair. Being thus provided; when a Hedge as G C bends in and out in several Places, and those Bends contain very small Spaces, lay the Hair over it lengthwise, so that the Quantities cut off from the Figure thereby may be equal to those added to it; and with your Protracting-pin near the Ends of the Hair make two Marks, through which draw a strait Line, and so will this irregular Side be reduced to a regular one. And here we may observe that in very small Bends, by the Eye, we judge better than we can by the Compaffes.

Lastly, if Hedges consist of large Curvatures (as in Fig. 18, 19.) chuse out such Points, and so many of them, that right Lines drawn from Point to Point, may vary the Quantity by such Quantities only as may be rejected. And herein your Hair will be a ready Assistance.



S E C T. VI.

The Use of the Theodolite exemplified in Surveying several Parcels of Land lying together.

AFTER a general Description of Instruments and their Uses, some practical Examples are necessary to illustrate and explain the particular Varieties which often occur.

The following Example I have handled in the same Method which I my self practise.

The Instrument which I use is a *Theodolite* numbered on the Limb from the Left to Right, and in the Box (which is fix'd to the Index) from the

Right

Right to the Left; the Eye being supposed in the Center.

The *Chain*, the *Off-set Staff*, the *Arrows*, &c. are as described in the third Section.

The Field Book I divide into three Columns. The middlemost contains the several Lengths taken by the Chain. The outermost Columns contain the several *Off-sets*, and the Description of the most remarkable Objects, which are to be met with in the Survey.

By the Mark $\odot$ I denote a Station, by $\sphericalangle$ I denote an Angle, by (B) I denote a Bearing, by *Int.* I denote a cutting a Hedge by the Chain, by *ag.* I denote some remarkable Object on the farther Side of the Hedge. These Symbols I have used instead of Words, because they constantly fall in the Way; but other Objects, which are more rarely met with, I express by Words.

Being thus provided, in the first Page of the Field-Book, near the Top, I enter the Title of my Survey: Then having fix'd my Instrument in some convenient Place, as A to begin at, I enter in the middle Column $\odot$ 1. denoting the first Station.

Here may be observed, that I always chuse to work in a Lane, as oft as Opportunity presents.

My Instrument being plant'd at A, I send a Station-staff forwards in the Lane as far as I can see distinctly, the farther the better, suppose to (B_3) and when I work in the Land, I send a Station-staff to the next eminent Bend in the Hedge, or even to the farther End of it, if the Line from the Instrument to the Staff be not at too great a Distance from the Hedge, so as to cause *Off-sets* greater than a Chain, or a Chain and a half, or thereabouts. For *Off-sets* taken too great, produce some Uncertainties.

First then, I observe the Bearing of the Line A B, thus, the Flower-de-luce in the Box being towards me, I direct the Sights to B_3 , and then find the Needle cut 327° , which I enter in the middle Column under $\odot$ 1. thus, $B_3 327^\circ$

The

The Observation being made of the Line's Position, which I am about to measure, the next thing is to lay the Chain from this Station A in a right Line towards the next Station B 3; which being done, I let it lie, till I have entred the Occurrences in this Chain's length, viz. I measure the Distances of the Chain from the Brow of each Ditch, which I enter in the outside Columns, that on the right Hand of the Chain in the right Hand Column, that on the left in the left Hand Column, and also the Names of the Persons who own these Lands abutting; or if these Lands are some of those which I am about to Survey, I enter the Names of them, and in all Cases express to which Land the Hedge belongs.

These Precepts I shall not repeat, though I shall ever make use of them; but if I use any other, I shall lay them down the first time I meet with them in this Example, but not afterwards.

First then, I enter 0 in the middle Column, and 20 in the right Hand one, and 20 in the left, denoting, that at no Distance, or at the Instrument, the Ditch on the right Hand is 20 Links from the Chain, and that on the left also 20. In the right Hand Column I write *William Wary's Land, Hedge to Wary*; and in the left, *Lord Title's Land, Hedge to Lord*; because the Land and Hedge on the right is *Wary's*, and that on the left *my Lord's*.

Being come to *a*, I am right against the South Hedge of *Hazle Spring*, and also of *Woodfield*, and there find the Distance from the Ditch on the right Hand to be 25, and on the left to be 20, and that afterwards the Hedge on the right Hand belongs to *Hazle Spring*, and on the left to *Woodfield*. Therefore I enter in the middle Column 65, and in the right Hand Column 25, *ag. Hedge on Hazle Spring*; Hedge to Spring; and in the left 20, *ag. Hedge on Woodfield*, Hedge to Field.

Here may be observed, that I always measure these Off-sets or Distances of the Chain from the Hedge

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Hedge (with my ten Link Staff, which I therefore call my *Off-set-Staff*) perpendicular to the Chain, and so far till I come to that Brow of the Ditch, which is farthest from the Stem of the Hedge: And that here by the Brow of the Ditch, I mean the determined Distance of five Links from the Stem of the Hedge. And in order to lay this Staff perpendicular to the Chain, it would be convenient to have two Pieces at one End of it at right Angles, like the Squares used on a Drawing-board; and these Pieces, for Convenience in Carriage, may be made to fall into the Staff, by Springs like a Clasp-knife.

Having entred my Observations in my first Length of my Chain, I observe what Place of the Ground is exactly under the Centre of my Instrument, by dropping a Musket Bullet; then I remove my Instrument, and in that place fix, as upright as I can, a Station-Staff, and then proceed with the Chain.

And because in the second and third Lengths of the Chain I meet with no sensible Turns in the Hedge, nor other material Occurrences, I go on to lay it a fourth time, and there against 45 Links I find a Bend in each Hedge; where on the right Hand the Brow of the Ditch is 50 Links distant from the Chain, and on the left 40; therefore in the middle Column I enter 345 (denoting 3 Chains 45 Links) and in the right Hand Column 50, and in the left 40.

And here may be observed, that I take Off-sets only at each End of such parts of a Hedge as run very nearly strait, omitting the intermediate Parts; since when the Extreams of a right Line are given, that right Line itself is also given: So here, though the Distance of the Hedges from the Chain between *a* and *b* continually vary, yet I only take the Off-sets at *a* and *b*, since these are sufficient. But when the Hedge runs on with a continued but irregular Curvature, I take Off-sets at every Chain or half Chain's length, or perhaps oftner, as the Thing requires. But when the Curvature is regular, I take

its Extremities by Off-sets, and express its Nature by a Sketch, in the outside Columns figured.

In going on from *b* towards *B*, when I am come to *c*, the Chain touches the Brow of the left Hand Ditch, against 20; then I ask the hindmost Man, How many Arrows he hath? he answers 5; then I enter in the middle Column 520 (denoting 5 Chains 20 Links) and in the left Hand Column 00, denoting that the Brow of the Ditch is at no Distance from the Chain. The Chain still lying against 40 Links, I find a Bend in the right Hand Hedge, where the Ditch is distant from the Chain 50 Links.

Now it may be observed, that I frequently ask the Follower of the Chain, and also the Leader, How many Arrows they have? especially when I am about the Off-set or other Occurrence, partly to know the Number of the Chains, and partly to prevent the Loss of an Arrow; for this always raises a Doubt of the Length, and must be removed before we proceed; and lest when a Stick is dropp'd, another may be pick'd up in its Room, I always give my Arrows some Marks of Distinction.

If the Sum of the Arrows in both my Assistants Hands are less than nine, then the last Length must either be re-measured, since it's doubtful, or else the Surveyor must step it, and thereby discover which dropt it: And this, with a little practice, he will easily do by counting his Steps, and using himself to step about the same Distance each Step; and by loosing a Button of his Coat when he hath gone as many Steps as (by Experience he knows) carry him the Length of a Chain. And hence he may know exactly the Number of the Chains, though he cannot perhaps find exactly the odd Measure. But the Number of Chains is sufficient, because the Error by dropping Arrows always falls in whole Chains.

In like manner, at the Length of just 800, because the Chain touches the right Hand Ditch, and is distant from the Bend in the left Hand 40 Links, I enter in the middle Column 800, in the right Hand Column 00, and in the left 40.

Then

Then I continue on to my Station-staff at B³, which I find to be at the Length of 825, where, because there is no Bend in the Hedge, nor other material Occurrence, I enter 825 in the middle Column, and under it I draw a Line, denoting that this Length, and all the Occurrences therein, are observed and entered in the Field book.

Since I have endeavoured to be plain and easy in this first Length; so shall I, in the following part of this Example, be as concise as I can, unless where I meet with Matter not before spoken of; referring the Reader rather to the Field-book and Explanations, than tiring him with Repetitions.

Being come to B³, I there so plant my Instrument by help of my Bullet, that its Center is directly over the Hole, which the Station-staff stood in; and I send my Station-staff forwards, as far as I can conveniently see it, as to C.

Now with the Beginning of the Degrees towards me, I direct the fix'd Sights back to the Staff at A, and then screw the Instrument fast: And then with the Flower-de-luce towards me, I direct the Index to the Staff at C, and there find, that the End of the Index next me, cuts $202^{\circ} 15'$, and the South End of the Needle points at $304^{\circ} 45'$. Therefore I enter in the middle Column of my Field-Book, O 2, and under it $< 202^{\circ} 15'$; and next under this B $304^{\circ} 45'$; denoting, that at the second Station, the Angle made, is $202^{\circ} 15'$, and the Bearing of the second Length is $304^{\circ} 45'$.

But before I proceed, I examine these Numbers thus: To the Bearing of the last Station 327° , I add the constant Number 180, and from the Sum 507° , I subtract the present Bearing $304^{\circ} 15'$; and find the Remainder $202^{\circ} 15'$, exactly equal to the Angle.

Or else, to the Angle $202^{\circ} 15'$, I add the present Bearing $304^{\circ} 15'$; and from the Sum 507° subtract the constant Number 180, so shall the Remainder 327° be the Bearing of the last Length, exactly, as taken at the last Station.

And this Operation I place in the outside Column against the same Angle and Bearing, to signify, that the Angle and Bearing have been compared, and do agree.

But if these Numbers thus compared, do not agree, the present Angle and Bearing must be examined and corrected; and if, after such Examination, they do not agree, there is an Error in the last Bearing, which may be taken again; thus,

The Instrument standing in the same Place, I direct the Index, the Flower-de-luce being from me, to the last Station Staff at A; and then will the South End of the Needle point at the same Degrees which it did when the Instrument stood at A, and the Index was directed to B³.

Having thus taken, entered and examined the Angle and Bearing, I proceed with my Chain, and find the Lengths and Occurrences to be as you see them in the Field-book.

Then fixing my Instrument, as before taught at C; I send my Station-staff forward to D, and observe, and enter, and prove the Bearing and Angle at C; and then stretching my Chain towards D, I find at the Length of 250, a Gate on my right Hand, and at 260, at the Distance of 10 Links, the Corner of *Hazle Spring*. Therefore in the middle Column I enter 250, and right against it, in the right Hand Column, I write *Gate*; Again, in the middle Column, I enter 260, and right against it, in the right Hand Column *10 Corner*. And then proceed to the Station-staff at D.

Having finish'd the Length CD, and fix'd the Instrument at the 4th Station D, I do not go up the Lane towards E, but turn off towards L; in order to close in *Hazle Spring* and *Spring Close*; always observing this Law, viz. Never to make a Tour greater than Necessity requires, but always to close as often and soon as possible.

Therefore having sent a Staff to L; I observe, enter and prove the Angle and Bearing at D.

Here

Here may be observed, that when I came to K in the first Length, the Hedge on the left Hand belonged to *Woodfield*, and not to the Lane; and therefore I entered in the left Hand Column, *Hedge to Field*; and since this Note, the Hedge on the left Hand hath continued to belong to the same *Woodfield*; therefore I have not repeated that Occurrence. But in going from D to L, at the Length of 15 Links, I am against the Corner of *Long Mead*, and 10 Links distant from it, and then the Hedge belongs to *Long Mead*. Therefore, after $\odot 4. > 259^{\circ}. 20'$, $B 261^{\circ}. 10'$, I enter in the middle Column 15, and on the left Hand 10 Corner, then on *Long Mead*, then *Hedge to Long Mead*.

But because on the right Hand we have still *Hazle Spring*, and the Hedge is still to the Spring, and because these have been always on the left Hand since I first entered them; I go on without any farther Remark, till I meet with a different Occurrence.

Being come to L, I observe, enter and prove the Bearing and Angle, and then proceed to M. At M I observe and proceed in like Manner to N. But at N, the seventh Station, instead of going on in the Lane, I proceed to close in *Hazle Spring*, and therefore send a Station-staff to O in *Spring Close*.

Therefore at the seventh Station N in the Lane, having observed, entered and proved the Angle M N O, and the Bearing of the Line N O, and directed the Chain from N towards O; I find the Chain cuts the Brow of the Ditch at 10 Links distant from N; therefore in the middle Column I enter 10 *Int.* denoting the Chain's intersecting the Hedge, and before I write *In Spring Close*, denoting that the Land we are in is called *Spring Close*; and in the right Hand Column, but the next Line, I write *Hazle Spring*, and under this, *Hedge to Spring*, denoting that the Land on our right Hand is *Hazle Spring*, and that the Hedge belongs to the same. Then I proceed to observe, measure and enter those Occurrences, as they are found in the Field-Book, till I come to O.

At O, I observe, enter and prove, and proceed as usual towards Q; noting that at the Length 720 the Chain did cut the Hedge in the very Corner of the Fence; and therefore enter in the Middle Column 720 *Int.* and in the right Hand Column 00 *Corner*, and then in the middle Column I write, *In William Wary's Land*; and so proceed to Q.

Being come to Q, the ninth Station, I send a Station Staff towards A; and then observe, enter and prove my Angle and Bearing; and so proceed with the Chain, entering all Occurrences, as in the Field-Book, till, coming to the Length 830, I find my self right against the Corner of *Hazel Spring*, and 43 distant from it; which being entered as you see in the Field Book, I write in the middle Column * *Close Hazel-Spring*, denoting that the Extremity of this Off-set co-incides with the first Off-set taken to *Hazel Spring*.

Having thus complicated *Hazel Spring*, I return to N, my Station in the Lane, according to that general Law I always observe, of working in a Lane, and according to that Law of closing as oft as possible.

Now, if I turn back the Leaves of my Field-book, I find the Station, immediately before my coming into *Spring Close*, was by Number the seventh. Therefore, in my Field-book, I enter © 7.

But here may be observed, That whensoever I design to return to the same Station, before I left it, I cut a Turf from the Hole where the Staff stood, or leave some other Mark, whereby I may exactly find it again readily; and in the Field-book to the Mark ©, I prefix the Letter R: by which, and the other concomitant Notes, I readily discover the Number of the Station.

Having now planted my Instrument a second Time at N, and sent a Staff forward to R, I observe the Angle M N R, made by the Line N R, I am next about to measure, and the Line M. N, that which measured immediately before I came to N the first time.

And

And this I always make a constant Law, viz. To observe the Angle with that Line which was measured immediately before I came to the Station, where I took the Angle the first time. So here I observe the Angle made with M N, and not with any other as O N, and therefore in proving the Angle M N R, I use the Bearing of M N taken at M.

Now having taken, enter'd and prov'd the Angle M N R, and the Bearing of N R, I go on with the Chain towards R, entering the several Occurrences as you find them in the Field-book.

Being come to R, the tenth Station, though my Design is to inclose *Spring-Close*, yet because the last Length, continued strait forwards, will take the South Hedge of *Long-Mead*; in the middle Column I enter $\odot 10$, $\angle 180$, and then direct the Leader of my Chain to lay it right forwards by help of the Stations R and N; and accordingly I enter the Occurrences of that Length, as you see in the Field-book.

This finish'd, I return to R, and sending a Station-staff to S, I enter again $\odot 10$, and the Angle and Bearing at R, and so proceed to S.

And then from S to T, and so from T the 12th Station to P, inclosing *Spring Close*.

Spring-Close being finished, I return to my fourth Station at D; and then send a Station-staff forwards to E, and then under $\odot 4$, observe and enter the Bearing of D E, and the Angle C D E; and then by the Bearing of C D, taken at the Station C, immediately before I came to D, prove the Angle C D E, and proceed with the Chain, entering all Occurrences as usual.

Being come to E, I send the Station to F, in order to close in *Woodfield*. Now, after I have observed and entred the Angle and Bearing at the thirteenth Station E, when I come to prove them, I find by adding 180° . to $353^\circ. 15'$, the Bearing of the Line which brought me to this Station; and when from the Sum $533^\circ. 15'$, I have subtracted 82° , the present Bearing, I find the Remainder to be $451^\circ. 15'$.

a Number greater than the 360. Now as oft as this happens, I lessen this Number by 360 Degrees, and so will the Remainder be, as in this Example, $91^{\circ} 15'$, the present Angle exactly.

Then entring the Occurrences, I proceed to F, and in like manner from F to G, from G to H, from H to I, and then from I, the seventeenth Station, to K, thereby inclosing *Woodfield*.

This done, I return to E, and there, because I can continue my Length D E, right forwards conveniently, I enter $\odot 13$, $\angle 180^{\circ} 00$, and then go on to V.

And then entring Angles, Bearings, and other Occurrences, I proceed from V to W, and from W to X, the 20th Station.

Being come to X, and having entred $\angle 234^{\circ} 20'$, and $B 307^{\circ} 40'$, then after I have added $180^{\circ} 00$ to the last Bearing $2^{\circ} 00$, I find the Sum $182^{\circ} 00$ is less than $307^{\circ} 40'$ the present Bearing: In such Cases I always add 360 to the Sum 182, and then from the Result, taking the present Bearing $307^{\circ} 40'$, the Remainder will be, as in this Example, $234^{\circ} 20'$, the present Angle.

Then I proceed to Y, and from Y to Z.

Being come to Z, the 22d Station, in order to enclose *Long Mead*, I go off to α , from α to β , from β to γ ; where, because the several Bends of the River cannot so commodiously be taken without it, from γ I go off to δ ; and then from γ to ϵ , from ϵ to ζ , from ζ to η , and from η the 28th Station, to θ ; thereby inclosing *Long Mead*. And then return to Z.

Being come to Z, I find it convenient to continue my Length strait forwards; and therefore under $\odot 22$, I write $\angle 180$, and so go on to λ , from λ to μ , from μ to π ; and then in order to inclose *Butts Close*, I go off from π , the 31st Station, to ρ , and ρ to σ .

Then returning to π , I go on to A^2 the 33d Station, and then, in order to close the *Home Close*, I go off to B^2 , and so then to C^2 , and D^2 .

Return:

Returning then to A^2 , I go on to E^2 , from E^2 to F^2 , from F^2 to G^2 , and from G^2 to H^2 , the 41st Station.

Being come to H^2 , in order to close in *Mottle Mead*, I go off to I^2 , from I^2 to K^2 , from K^2 to L^2 , the 44th Position, and from L^2 to M^2 , and so is *Mottle Mead* finished.

Then in order to inclose *Hazle Wood*, I go from L^2 to N^2 , from N^2 to the Angle at F , and so is *Hazle Wood* finished.

Then I return to H^2 the 39th Station, and thence go to O^2 , and from O^2 to P^2 , the 45th Station.

And now, in order close in *Hazle Field*, I go from P^2 to Q^2 , and from Q^2 to T^2 .

Which being done, I go from P^2 to R^2 , and from R^2 to S^2 ; and so the whole is finished, as you find it in the Field Book; and as far as relates to the Field Work.

It remains to shew, how this Work may be plotted without any regard to the Memory; nay, though it were survey'd by one Person how it may be plotted by another who never saw the Land; provided that the Person who survey'd it, hath strictly observed the Laws here laid down. And I do affirm, that any Method of keeping a Field-book, which lays a Burthen on the Memory, or by which, a Person remote from the Land, cannot plot it, is imperfect, and ought not to be practised.

But it may not be improper, to advertise the Reader, That there is one Thing absolutely necessary to be taken Notice of, in observing with any of the foregoing Instruments, viz. That the Plate lie always parallel, or very near parallel to the Plan of the Horizon.

Secondly, He ought to allow for the Difference between ascending and descending Lengths, when compared with the horizontal Length.

For it is evident, That the Length measured up an Ascent, or down a Descent, will be always greater than the horizontal Lengths, which only are the Measures, which ought to be entered, either for

Casting or for Drawing the Plans of any Parcel of Lands whatsoever: Since these ascending Measures, if laid down, would crowd the adjacent out of their Places.

And since these Things are required very frequently, many Times in going up one Ascent, and consequently ought to be performed in the Field, in order to make a proper Entry in the Book; I would have the Practitioner be provided with such a *Theodolite*, as will perform without Compasses, Rules, Sectors, Tables, &c. these useful Practices, or without any further Observations than what is required to take the Angle only. Such *Theodolites* may be made, not only to perform these, but also to shew by Inspection, the Height of any standing Stick of Timber, without any Calculation, tho' the Stick stood on level, rising, or falling Ground: Or the Length of any Arm out of Reach; or Height of any Steeple or Hill: Or by it a Level proper for the conducting of Water; Very proper for all Surveyors in general.

Tho' I do design to give you a Specimen of this improved Instrument, after this Example, in all its Conveniencies, I could not pass it by in this Place, lest the Reader should over-look it.



SECT.

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S E C T. VI.

To protract the Observations contained in the preceding Field-Book.

FIRST, I draw parallel right Lines, as those in the Scheme mark'd N S, representing Meridians or North and South Lines, at a Distance from one another, not exceeding the Breadth of the diametrical Part of the *Protractor*.

Then picking out some convenient Place to represent the first Station, as A; my Field-book being open before me, I lay the Center of the *Protractor* on the Point A, and the Diameter parallel to the Lines N S, and the beginning of the Degrees downwards, because the Bearing is more than 180; then against 327 Degrees, I make a Mark with my *Protracting Pin*, to which I draw an obscure Line from A, representing the Chain-line from the Station A to the Station B.

Then to this obscure Line, I lay the Edge of my *Plotting Scale*, the beginning of the Divisions coinciding with A, and increasing towards the next Station B, and because the Off-sets, in the first Length, are taken at the Distances 65, 345, 520, 540, 800, 825; therefore, against these Numbers on the Scale, I make Marks in the obscure Line close to the Edge of the Scale.

This done, I turn my Scale perpendicular to the obscure Line, and apply it successively to these several Points, and there prick off the Lengths of the several Off-sets on their respective Sides of the obscure Line; so at A, I prick off 20 on the right
H 2 Hand,

Hand, and 20 on the left; at the Length 65, which is the next Point, I prick off 25 on the right Hand, and 20 on the left; and at the next Point, which is at the Distance 345, I prick off 50 on the right Hand, and 40 on the left; at the fourth Point, which is at the Distance 520, I prick off 00 to the left Hand; at the fifth Point, which is at the Distance 540, I prick off 50 to the right Hand; at the next Point, which is at the Distance 800, I prick off 00 to the right Hand, and 40 to the left; at the last Point, because no Off-set was taken, I lay none down.

And now, if Lines are drawn from Point to Point on each side of the obscure Line, they will represent the Fences as was required. But when the Off-set is 00, as in the fourth and sixth Distances, those Points, to prevent being overlook'd, should be mark'd with a black-lead Pencil, or something else, which may be easily rubb'd out again.

At the second Distance, where we were against the South Fences of *Woodfield* and *Hazle-spring*, with a black-lead Pencil draw two short Lines, cutting the Lane, to denote, that the South Fences come up to the Lane, and will hereafter be of use in closing these Plots.

Having thus finish'd my first Length, I produce it, if Occasion require from B, both Ways, till it is as long each Way as the *Radius* of the *Protractor*. Then I place the Center of the *Protractor* on B, and thereon turn it about, because the Degrees of the next Angle are more than 180, till the Beginning of the Degrees of the *Protractor* are contrary to the last Station A, and the Diameter coincident with A. B. Then close to the Edge of the *Protractor*, right against 202. 15, I make a Mark with my *Protracting-Pin*, and to it from B draw an obscure Line representing the Chain Line from B to C.

Then I turn the *Protractor* about, the Center still coinciding with B, and because the Bearing is more than 180, the Beginning of the Degrees towards S, and the Diameter parallel to the Meridians; and then, if you have truly wrought, the Line B C before

fore drawn, will meet the Limb of the *Protractor* against $304^{\circ} 15'$, the Bearing of the Line B C.

But if it doth not, the Line B C is not in its true Position, and must be corrected before you proceed.

Or thus; The Center of the *Protractor* coinciding with B, I turn it about till the Beginning of the Degrees is towards S, because the Bearing is greater than 180 , and till the Diameter lies parallel to the Meridians; and then close to the Edge of the *Protractor*, with my *Protracting-Pin*, I make a Mark against $304^{\circ} 15'$, the Bearing of the Line D C, and to it from B draw a strait Line representing the strait Line B C. Then turning the *Protractor* about on the Center C, and because the Angle there taken was of $202^{\circ} 15'$, more than 180 , I turn the Beginning of the Degrees of the *Protractor* contrary to the last Station A, and the Diameter to agree with A B; and then will B C meet the Limb of the *Protractor* against $202^{\circ} 15'$, if the Bearing is truly laid down.

And thus the Plot may be laid down by the Bearings, and examined by the Angles.

Then to this obscure Line, I apply the Edge of my *Plotting-Scale*, the Beginnings of the Divisions coinciding with the present Station B, and the Numbers increasing towards the next C; and then close to the Edge thereof, against 240 , 250 , the Lengths where the Off-sets were taken, I make Marks with my *Protracting-Pin*. This done, I turn my Scale perpendicular to the obscure Line, and at 240 , I prick off 15 to the left Hand, and against 250 , which gives the Point C, I prick off 10 to the right Hand, as the Field-book directs. Now continuing the Fences to these Off-sets, I shall have finish'd the second Length from B to C.

The second Length thus finish'd, I produce it, if Occasion require, from C both ways, till the Length each way be at least equal to the *Radius* of the *Protractor*. Then I place the Center of the *Protractor* on C, and because the Degrees of the Angle at C are less than 180 , I lay the Beginning of the Degrees of the *Protractor* towards B, the last Station, and the
Diameter

Diameter on B. C. Then close to the Edge of the *Protractor*, with my *Protracting-Pin*, I make a Mark against $144^{\circ} 45'$, the Quantity of the Angle at C, and to it draw an obscure right Line from C, representing the Line from C to D.

Then turn the *Protractor* about, its Center still coinciding with C, because the Bearing is more than 180 , the Beginning of the Degrees towards S, and the Diameter parallel to the Meridians, and then if you have work'd truly, the Line C D before drawn, will meet with the Limb of the *Protractor* against $340^{\circ} 30'$, the Bearing of the Line C D.

But if not, the Line C D is not in its true Position, and must be corrected before you proceed.

From the laying down these two Angles and Bearings, it appears how Errors often happening in Practice, may be prevented.

The general Laws I observe herein are Three, *viz.*

1. I lay the Diameter of the *Protractor* on that Line which brought me to the present Station, where the Angle, about to be laid down, was taken.

2. I lay the Beginning of the Degrees of the *Protractor* towards the last Station, when the Angle is less than 180 Degrees; but the contrary way, when the Angle is more.

3. In laying down or examining the Bearing, I lay the Beginning of the Degrees of the *Protractor* Northwards, when they are fewer than 180 ; but Southwards, when more.

In like manner I lay down and examine the Angles and Bearings taken at D, L, M, N, O, Q, the 4th, 5th, 6th, 7th, 8th, 9th Stations, and also the corresponding Lengths and Occurrences. But in the last Length Q A, having at the Length 830 laid off an Off-set of 43, it gives exactly that Corner of *Hazle-spring*, which was noted down in the first Length in the Lane; which proves that the Angles

gles and Lengths inclosing *Hazle-spring* are truly laid down. But if the Extremity of the last Off-set in the Length Q A doth not coincide with the Extremity of the second Off-set A B, both denoting the South-West Corner of *Hazle-spring*, the Lengths and Angles designed to inclose the same *Hazle-spring* are not truly laid down, and therefore must be examined and corrected before you proceed.

Now © 7, being mark'd with 7, a Number not greater than 9, the Number of the last Station, being the next Work noted in my Field-Book; I return to © 7, in my Draught, and there with M N, the Line which I measured immediately before I came to N, I make the Angle M N R $162^{\circ}. 45'$, and the Bearing of N R $274^{\circ}. 45'$, as noted in the Field-book, and then proceed to lay down the Off-sets and other Occurrences, at their proper Lengths and Distances, as noted in the Field-book.

Having finished N R, I find next following in my Field-book © 10, which because it is greater than 8, the Number which immediately follows 7, the Number of the last Station; and because I find no Station already laid down, mark'd with a Number so great as 10, therefore conclude, that the Station R, where I now am, is to be numbred 10; and from thence proceed to lay down and examine the Angle and Bearing at R, as usual.

The Laws I observe in these Cases are,

1. To number with black Lead all the Stations I have already laid down in my Draught, and also to express those Numbers successively after one another, in a Piece of waste Paper, which I examine as oft as I please.

2. If I come to a Station whose Number doth not immediately succeed the Number of the last Station, but is greater than the greatest of those Numbers noted in my waste Paper by an Unite, then at the Station now arrived at, I lay down and examine the Bearing and Angle with the Line I measured immediately

diately before I came to this Station. And this Station I number as denoted in my Field-book.

30 If I come to a Station, whose Number doth not immediately succeed the Number of the last Station, but is greater than the greatest of those Numbers noted in my waste Paper by more than an Unite, then some Omission hath arose in my waste Paper, and must be rectified before I proceed.

4. And lastly, If I come to a Station whose Number is already entred in my waste Paper, then I return to that Station in my Draught, and there lay down and examine the Bearing and Angle with the Line, measured immediately before I came to this Station, the first Time.

Now the next Observation I meet with in my Field-book, is again © 10; Therefore again at © 10, I lay down and examine an Angle and Bearing, as noted in the Field-book, and then proceed to lay down the Lengths and Off-sets of the Line R S, as I find in my Field-book.

Being come to S, I proceed to T, and from T to P, there closing with the Extremity of the Off-set at P, coinciding with the South-West Corner of *Spring Close*, and the South-East Corner of *Hazle Spring*.

This done, I find next in my Field-book © 04; therefore I return to © 4, and there proceed as my Field-book directs, till I come to Station 13; and because this is a Number greater, by an Unite, than 12, the Number noted in my waste Paper, I number it 13, and then proceed, as my Field-book directs, to F, G, H, I, and K, there closing in *Woodfield* by the Extremity of the Off-sets there laid down.

This done, I next find © 13, and therefore, because already entered in my waste Paper; I return to © 13 in my Draught. And then proceed as before shown, till I have plotted all the Occurrences mentioned

mentioned in my Field-book ; But the remaining Part hereof I leave for the Exercise of the Reader.

I think I need not detain the Reader with the Manner of transferring the Draught to his Vellom ; of drawing a Scale and a Compass, ever allowing the Variation of the Needle ; of entring the Contents of each Piece ; and the Ornaments to be met with on every Draught.

I shall only add, That the Representation of the Hedges ought to be laid down on the same Sides of the Fences, that they are in the Land ; and to be broke off where there are to be the Representations of Gates, &c.

That there ought to be imaginary Lines, both Vertical and Horizontal, denoted by Letters placed at the Top and Bottom, and also on the Sides, to be referred to by the Table of References ; for the ready finding any Field, or Parcel of Land therein contained.

Lastly, I shall, in this Place, only add, That in all Performances of this Kind, Errors, for the most Part, arise from the Defects of Instruments, in the Framing, Dividing and Contriving.



I

Obfer-



Observations and Dimensions of Lands
lying in the Parish of — in the
County of — Part of the Estate
of —

February the 2d. 1725.

Beginning at the Lane leading from Hardly to
Roughton.

	⊙ 1	
	B 327. 00	
On Lord Title	20	0
Hedge to Lord		
ag. Hedge	20	65
On Woodfield		
Hedge to Field	40	345
	00	520
		540
	40	800
		825
	⊙ 2	
	202. 45	
	B 304. 45	
	15	240
		250
		10

327 00
180. 00
507. 00
304. 15
202. 45

[59]

304. 15
180

484. 15
340. 30
143. 45

340. 30
180
520. 30
261. 10
259. 20

Corner 10
On Long Mead
Hedge to Long Mead

261. 10
180
441. 10
284. 20
156. 50

284. 20
180
464. 20
257. 50
206. 50

257. 30
180
437. 30
173
264. 30

⊙ 3

143. 45
B 340. 30
250
260
270

Gate
10 Corner

R ⊙ 4

259. 20
B 261. 10

15

220

⊙ 5

156. 50
B 284. 20

165

⊙ 6

206. 50
B 257. 30

230

10 against Hedge
On Spring Close
Hedge to Spring Close

240

R ⊙ 7

264. 30
B 173. 00
10 Int.

In Spring

Close
On Hazle Spring
Hedge to Spring

135

245

07

15

1 2

[60]

173. 00
180
353. 00
150. 45
202. 45

In William

150. 45
180
330. 45
90. 45
240. 00

Taken from © 6
257. 30
180
437. 30
274. 45
162. 45

15
50
35

R

30
20
60

© 8

> 202. 15
B 150. 45

154
335
550
720 Int.

Wary's
825

© 9

> 240. 00
B 90. 45

90
510
640
755
830

© 7

< 162. 45
B 274. 45

40
230
230
260
350

© 10

> 180. 00
B 274. 45

0
60
100
160

11
50
35
00 Corner.

Land

20

05

70

15

43 Corner

Close Hazle-spring

Gate

05

*10 against Hedge and
Corner of Spring-close.*

On Tho. Coles

20

40

274

274. 4
180
454. 4
208. 2
246. 2

208. 2
180
388. 2
180
208. 2

180. 0
180. 0
360. 0
85. 0
275. 0

Taken
340. 3
180
520. 2
353. 1
161. 1

On W

[61]

274. 45
180
454. 45
208. 20
246. 25

In Tho.

⊙ 10
246. 25
B 208. 20

10 Int.
Coles

Land
Hedge to Spring
Close

300
340
370

100
10

208. 20
180
388. 20
180
208. 20

⊙ 11
208. 20
B 180. 00
00
630
680

18
15 Corner

180. 00
180. 00
360. 00
85. 00
275. 00

⊙ 12
275. 00
B 85. 00
20

Corner
on Spring-close
Hedge to Spring Close
00
20 Corner
Close-spring-close

400
870

Taken from ⊙ 3
340. 30
180
520. 30
353. 15
161. 15

⊙ 4
167. 15
B 353. 15

On Woodfield

10

10 Corner of
Long Mead
Hedge to Long Mead
00

Gate 20

440

353

[62]

353. 15
180
533. 15
82. 00
451. 15
360
91. 15

82. 00
180
262
163
99

163 00
180
343
93. 15
249. 45

93. 15
180
273. 15
195. 40
77. 35

R 013
91. 15
B 82. 00
20 Int.
20
550

014
99. 00
B 163. 00
00

550
015
249. 45
B 93. 15

35
430
600
610

835

016
77. 35
B 195. 40
00
320
500
650
742

In Woodfield
15 Corner of Hazle.
(Wood
Hedge to Wood
15

10 Gate
On Wood-Close
Hedge to Woodfield

30

00 Corner
130
100
50 against Hedge
and Corner of Woodfield
On Lord Titles Land
Hedge to Title
10 Corner

00
210
00
135 Corner

190. 40
180
375. 40
246. 30
129. 10

against H
On Hazl
Hedge to

353. 15
180
533. 15
350. 30
182. 45

350. 30
180.
530. 30
2. 00
528. 30
360
168. 30

[63]

190. 40
180
 375. 40
246. 30
 129. 10

Hazle.
 Wood

against Hedge
 On Hazle Wood
 Hedge to Wood

353. 15
180
 533. 15
350. 30
 182. 45

350. 30
180.
 530. 30
2. 00
 528. 30
360
 168. 30

odfield
 and

⊙17

✓ 129. 10
 B 246. 30
00
 610

15
 15 Corner

⊙13

✓ 180. 00
 B 353. 15
20

20

25

140

00

⊙18

✓ 182. 45
 B 350. 30

10

10

360

20

445

20

⊙19

✓ 168. 30
 B 2. 00

00

25

25

15

10

30

30

100

255

350

440

520

595

663

20

05

00

10

20

30

70

[64]

2. 00
180.
 182. 00
360
 542. 00
307. 40
 234. 20

against Hedge
 On Buts-close
 Hedge to Close

307. 40
180
 487. 40
287. 00
 200. 40

287. 00
180
 467. 00
186. 20
 280. 40

Gate 75
 30
 20

60

60

170

215

450

21

> 200. 40
 B 287. 00

20

20

75

70

25

150

260

275

380

400

510

R 22

> 280. 40
 B 186. 20
 10 Int.

27

360

540

735

Gate

00 against Hedge and
 Corner of Long Mead
 On Walter's Meadow

In Walter's Meadow
 110 Corner
 On Long Mead
 Hedge to Long Mead

15

190

10

186.
 180.
366.
166.
 200.

On T

166.
 180
346.
111
 235.

111. 0
 180
 291
229. 2
 61. 4

[65]

186. 20
180.
366. 20
166. 15
200. 05

©23

> 200. 05
B 166. 15

10 Int.

In Long Mead

Corner 10
On Trout Beck

20
00 50
10 150
10 235
245

166. 15
180
346. 15
111
235. 15

©24

< 235. 15
B 111. 00

10 40
20 105
00 255
25 345
460

111. 00
180
291
229. 20
61. 40

©25

< 61. 40
B 229. 20

30 80 30
30 120 35
150 35
25 160 50
170 40
10 200

K

[66]

111. 00
180
261
192. 30
128. 30

162. 30
180
342. 30
251. 30
91

251. 30
180
431. 30
250. 30
141. 00

290. 30
180
470. 30
179. 30
291. 00

On Tho. Coles
Hedge to Cole

15 145
50 190
10 430
30 535
585
128. 30
162. 30

15 145
50 190
10 430
30 535
585
128. 30
162. 30

15 145
50 190
10 430
30 535
585
128. 30
162. 30

15 145
50 190
10 430
30 535
585
128. 30
162. 30

15 145
50 190
10 430
30 535
585
128. 30
162. 30

15 145
50 190
10 430
30 535
585
128. 30
162. 30

15 145
50 190
10 430
30 535
585
128. 30
162. 30

287.
180
467
2.
464.
360
104.
On B

167
180
347
220
126

[67]

287. 00
180

467
2. 10

464. 50
360

104. 50
On Buts-close

In
Corner. 00
Roughton
30
65

Common

86
00
65

230
480
635

030
89. 00
B 93. 10
65 Int.
In Buts Close

100
350
750
835

R

031
100. 00
B 167. 10
0

590

032
126. 40
B 220. 30
0
85

415

On Roughton Common
65
100
100
15

20 On Home-close
Hedge to Home-close
15

10
10 against Hedge
On Hazle Wood
Hedge to Wood
10

167. 10
180. 00

347. 10
220. 30

126. 40

93. 10
180
273. 10
180. 30
92. 40

180. 30
180
360. 30
238. 20
122. 10

238. 20
180
418. 20
308. 30
109. 50

93. 10
180
273. 10
102. 00
371. 10

R

031

<180. 00

B 93. 10

20 Int.

In Home

195

195

750

033

> 92. 40

B 180. 30

00

625

735

034

> 122. 10

B 238. 20

00

310

035

> 109. 50

B 308. 30

00

485

033

> 171. 10

B 102.

10 Int.

In Mottle

300

315

Gate

Close

On Roughton-common

30

75

10

On Mottle Mead

Hedge to Home-close

15 against Hedge

On Hazle Wood

Hedge to Wood

20

10

10

10

10

Mead

On Roughton-common

25

102. 0
180
282 0
82
200

82. 0
180
262. 0
125. 2
136. 3

125. 3
180
305. 3
201. 5
103. 4

201. 5
180
381. 5
279. 2
102. 3

279. 2
180
459. 2
177. 1
282. 0

177. 1
180
357. 3
271. 5
85. 2

[69]

0 1
102. 00
180
282 00
82
200

82. 00
180
262. 00
125. 30
136. 30

125. 30
180
305. 30
201. 50
103. 40

201. 50
180
381. 50
279. 20
102. 30

279. 20
180
459. 20
177. 15
282. 05

177. 15
180
357. 30
271. 50
85. 25

⊙36

> 200 00
B 82. 00
70
150
380
600
770
708

65
10
60
15
15
10

⊙37

> 136. 30
B 125. 30
00
100
260

15
30
30 against Hedge

⊙38

> 103. 40
B 201. 50
00
255
270

On Lord Titles Land
Hedge to Lord
60

⊙39

R > 102. 30
B 279. 20
00
295
605
620

30 On Hazle Field
Hedge to Mottic Mead
35
15 Corner

⊙40

> 282. 05
B 177. 15
370

10

⊙41

> 85. 25
B 271. 50
00
235

15
15

[70]

⊙42

> 180. 00
B 271. 50
20

15 against Hedge
On Hazle Wood
Hedge to Hazlewood
15

375

⊙42

> 268. 50
B 183. 00
15 Int.

271. 50
180
451. 50
183. 00
268. 50

On Hazle Wood
Hedge to Wood

In Hazle Field

25
Corner 10

375
760
790

183. 00
180

363
209. 30
153. 30

270
Corner 00

⊙43
> 153. 30
B 209. 30
230
445 Int.

In Wood Close

25
30

650
860

Corner of
Hazle Wood
and Woodfield

201. 50
180.
381. 50
185. 15
193. 35

⊙39
> 196. 35
B 185. 35
30
30 Int.

20 Corner

On Lord Titles Land
Hedge to Lord

400
365
1100

165
100
10

185.
180
365.
171.
193.

171.
180
351.
270.
81

270. 30
180
450. 30
338. 00
112. 30

[71]

185. 15
180
365. 15
171. 30
193. 45

⊙44
V 193. 45
B 171. 30
200 110
345 30
440 70
520 20

171. 30
180
351. 30
270. 30
81

⊙45
V 81. 00
B 270. 30
15 45 On Wood-Close
Hedge to Woodclose
100 65
340 95
650 75
740 80
990 13

270. 30
180
450. 30
338. 00
112. 30

⊙46
V 112. 30
B 338. 09
00 10
200 15 ag. Hedge
On Hazle-wood

⊙45
V 180. 00
B 171. 30
15 10 Corner
35 Int. On Lord Titles Land
Hedge to Title
255 30
300

Land

[72]

171. 30
180
 351. 30
251. 00
 100. 30

47
 100. 30
 B 251.

25	100
240	230
330	175
310	125
640	00
680	

120 against Hedge
 On Woodfield



SECT.

Lands

Tides

Lord

The

Mottle

Mead

Home
Clove

Butts
Clove

Hazle
Field

Hazle

Wood

Long Mead

Common
Mead

Wood Clove

Wood Field

Hazle

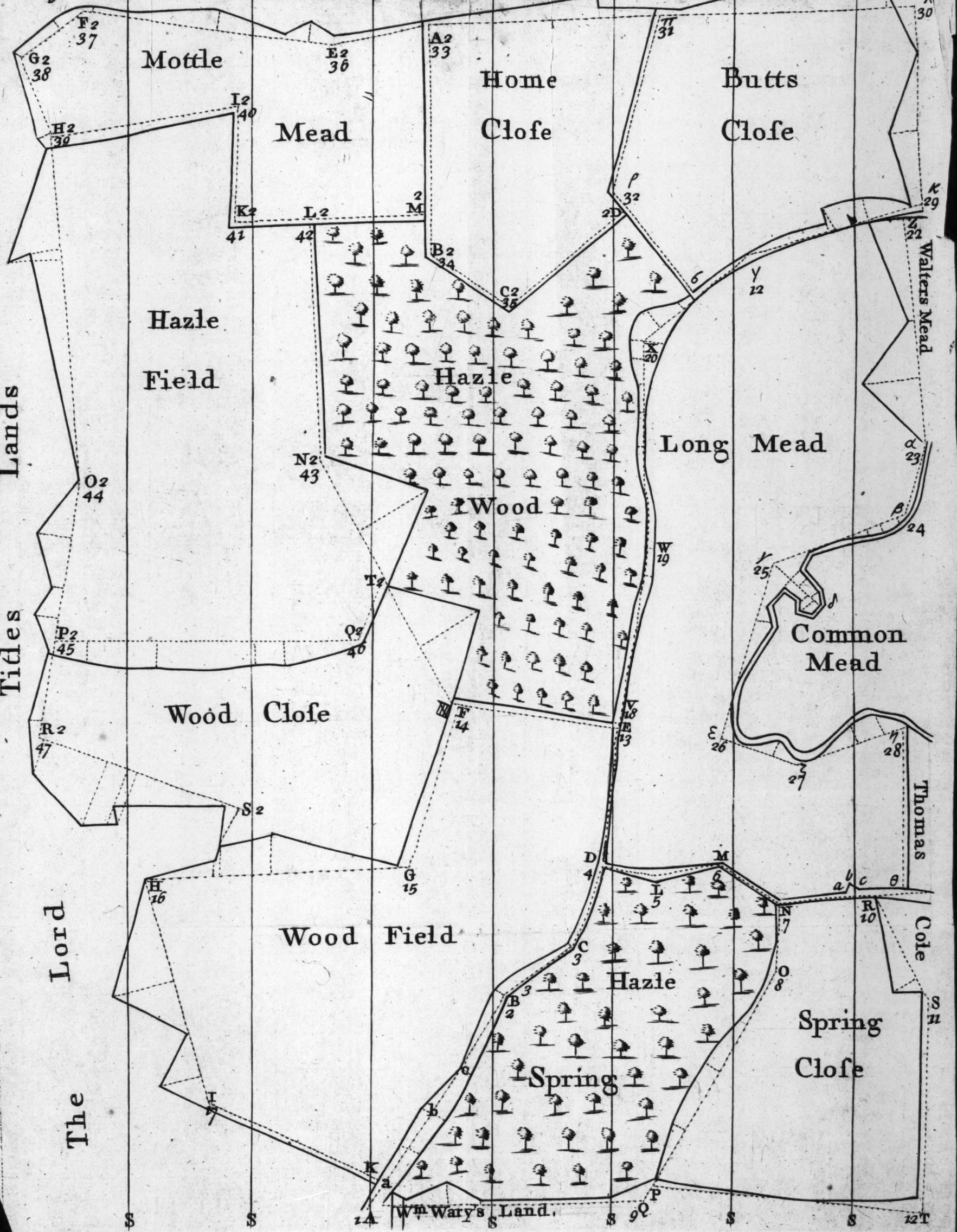
Spring

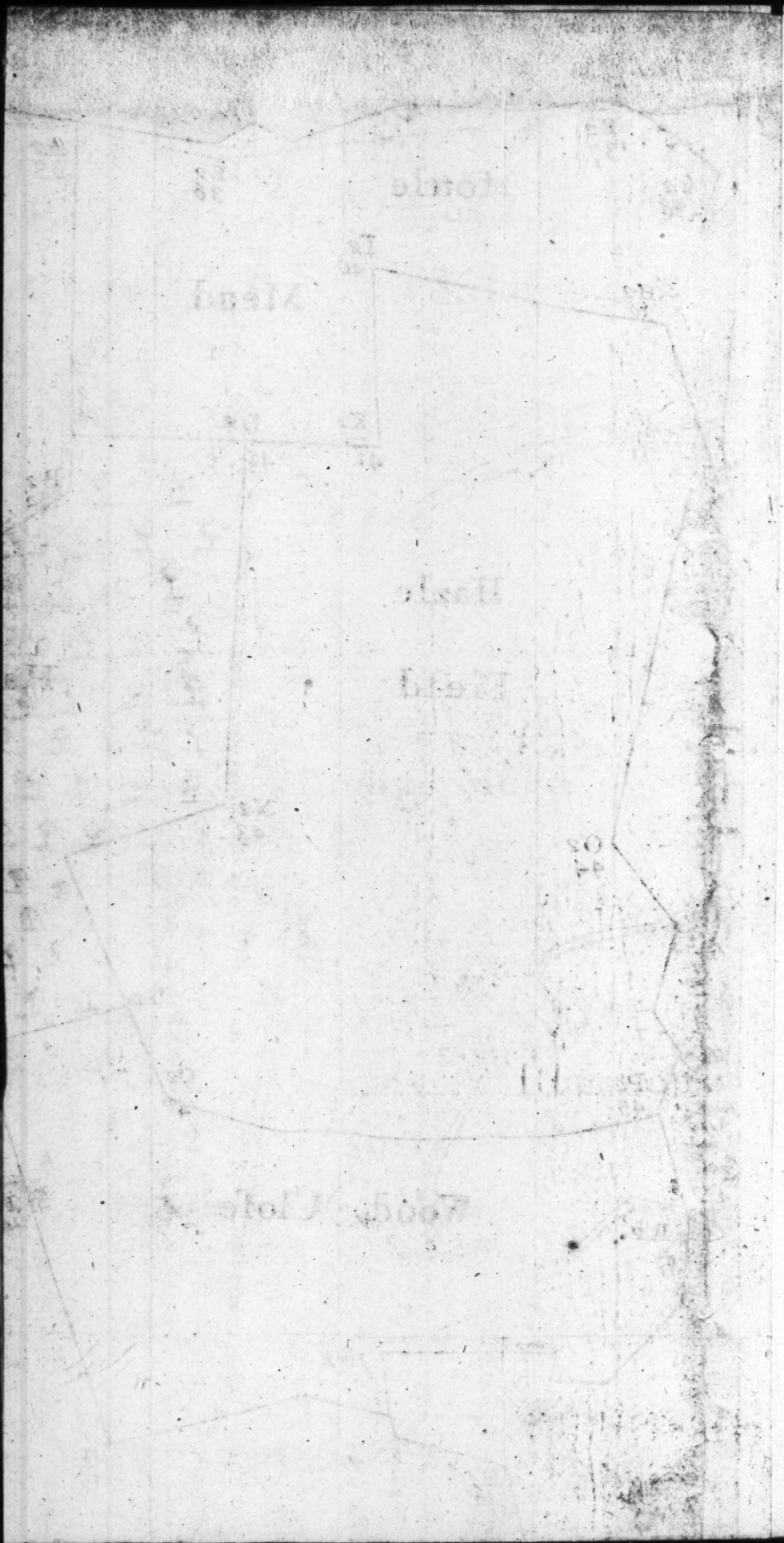
Spring
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S E C T. VII.

A farther Use of the Theodolite (as now improved); conjointly with the Use of a Sliding Rule aptly divided; to measure Timber, either round, or hewn to a Square, or unequally squared.

THE principal Difficulty in using this Sliding Rule, is, in justly distinguishing the Value of each Division. And in order to this, it may be observed, That the Divisions on this Rule, may be distinguished into Three Orders: *viz.* the Longest, the Mean, the Shortest. And these distinguish their Value in a Tenth Proportion, as the Places of Numbers in Arithmetick.

So that, if the longest represent Hundreds; the mean will represent Tens, and the shortest Units.

And if the longest represent Tens; the mean will represent Units, and the shortest Tenth Parts.

Also, if the longest represent Thousands, the mean will represent Hundreds, and the shortest Tens; and in this Case, the Units must be estimated by the Eye, in judging at Divisions, only supposed to be drawn, because there is not Room enough.

The longest Divisions are generally numbered by the Figures, by 1, 2, 3, 4, 5, &c. and when they are numbered thus, 1, 2, 3, 4, 5, 6, 7, 8, 9, 1, 2, 3, 4, 5, 6, 7, 8, 9, 1: the Line is called a double one. And when the longer Divisions are in Number only Ten, and numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 1; or numbered 5, 6, 7, 8, 9, 10, 20, 30,

30, 40, 50 ; or broken so as to begin at any other Number, so as to contain only Ten long Divisions ; the Line is called a single one. And these are called *Gunter's Lines*, from the Name of their Author.

But we may observe, That these Divisions represent equal Distances ; yet, from their Use, cannot be so. Nor will be easily capable of equal Numbers of Divisions, in different Parts of the Rules ; either of mean, between the longest, or of the shortest between the mean.

But in order to make this easy, here follows an Explanation of the Divisions laid down on the Foot Sliding Rule, which may easily be applied to other Rules of greater Length ; where the Multitude of the intermediate Divisions may be greater.

On the Slider, are Two of these double Lines, both alike ; one of which moves against the fixed Line above, which is also exactly like to either of the other ; and the undermost Line on the Slider, moves against a single Line, beginning with the Numbers 5, 6, &c. and going on to 50.

If the first 1 be called an Unit, the following numbered Divisions, till you arrive at the Middle 1, will be Units. And the mean Division will be Tenth Parts.

If the first 1 be called Ten ; the Figures 2, 3, 4, &c. immediately following it, will denote 20, 30, 40, &c. And the mean Divisions, that is the next longest in Order, will denote Units ; the fifth of which is, for Distinction, made longer than the rest. And from 10 to 20, between each of these mean Divisions, the shortest denote each Two Tenth Parts ; because the Distances between the mean Divisions, are divided into Five Parts ; but if the Distances between these mean Divisions were divided by shorter Lines into Ten Parts, which is seldom done on Rules so short, each would represent one Tenth Part.

In like manner from 20 to 30, that is, from the Divisions mark'd 2, 3, the same follows ; save that the Distances between the mean Divisions (because of

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of their Nearness to one another) are divided into Two Parts only; and consequently each of these shortest Divisions will denote Five Tenth Parts; and the Eye must estimate the other Tenths not cut, but supposed to be cut between them: Tho' in larger Instruments, even here, and elsewhere, the shortest Divisions may be as many as those between the 10 and 20.

This last Multitude of Divisions, usually continues to 40, 50, or perhaps farther, and are to be read as those between 20 and 30.

But when the longest come closer together, as generally they do, between 80 and 90, and between 90 and 100, which, on the Scale, is denoted by the Digits 8, 9, 1, there are but Two Orders of Divisions; the greatest still keeping the same Degree, and the other the next lower Degree. And in this one Example, the figured Divisions denote Tens, and the others Units.

But when the first 1 is called 100; then the figured Divisions will be accordingly 200, 300, 400, &c. The mean Divisions, or the next shortest Division, will denote Tens. The shortest between 100 and 200, where the Distance between the Tens is divided only into Five Parts; I say, the shortest here will denote Two Units each of them; and the Middle between these, will denote the single Units; which, if there had been Divisions, as in large Instruments, would have been denoted by those Divisions.

But from 200 to 300, from 300 to 400, and from 400 to 500, the Distances of the Divisions representing Tens, are divided only into Two Parts, and consequently, each of these shortest Divisions must represent Five Units; and all other Units, either more or less than Five, must be estimated by the Eye, by supposing each of these Distances cut into Five Parts. Nevertheless, in larger Instruments, these Divisions may be cut and estimated as before shewn.

Towards the latter End of the Line, the Divisions on these short Lines are so near together, that they scarce admit of Three Orders of Divisions, and consequently (supposing the longer Divisions to denote Hundreds, as in this Example) the Units must be estimated by the Eye.

And in like manner, if the longer or figured Divisions, denote Thousands, the Lines of lesser Length will denote Hundreds, the next Inferior, Tens, &c.

But because, by Inspection, on this Rule it will appear, That more than Three Places cannot be distinctly estimated. And, That those are sufficiently exact for all the Uses it is designed for, a farther Division, and Considerations thereon, are omitted.

If the first 1, that is the Beginning of the first Line, denotes a Unit; then the middle 1, or beginning of the second Line, denotes 10, and the last 1 denotes 100.

So, if the first 1 denotes 10; the second 1 denotes 100, and the last 1000.

In like manner, if the first 1 denotes 100; the second denotes 1000, and the last 10,000.

And since, when the Value of the first 1 of any Line is known, the Value of the other Figures and Divisions are known also; therefore the latter Line is to be read by the former Directions. And thus are these Three double Lines to be read, as has been shewn, for the former.

But the single broken Line, which is on the fixed Part of the Leg of the Rule, is not to be considered in this arbitrary Manner.

For the longer Divisions have affixed to them their Values, which ought to be considered as unvariable, unless in some particular Necessities hereafter to be taken notice of.

From the Beginning of this Line, to the Division mark'd 10, the Distances of the longer Divisions, which are numbered 5, 6, 7, 8, 9, 10, are divided into 10 Parts by mean Divisions; and therefore, these mean Divisions denote Tenth Parts. And these

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mean Divisions are each subdivided by one short Line, each denoting therefore Half of one Tenth.

From 10 to the End of the Rule, the Distances between the longer Divisions, are each divided into 10 Parts; and therefore each denotes Units. And the Distances between the Units are each divided into 4 Parts; therefore each denotes one fourth Part of an Unit.

The uppermost of these double Lines is mark'd with the Letter A, the next with B, the third with C; and undermost, which is also called the Girth-Line, with D.

On the Lines A and B, there are placed the small Figures ¹², denoting an Index fix'd, tho' the Values of the Divisions should vary.

And, on the Girth-Line, against 12, is generally a Hand or Index for the like Use.

The Two upper Lines are generally used for casting up the Surfaces of Planks.

The Two under ones for Timber.

Having thus far described and explained the reading of this Rule; I shall proceed to shew its Use in measuring Planks and Timber. But shall first shew the Customs used in taking their Dimensions.

And first for Planks; The Buyer hath the Liberty of measuring the Dimensions on that Side of the Plank he judges most advantageous to himself.

Then the Length is measured either with Two Two-foot Rules, or Two-foot Rules, and Five or Ten-foot Rods.

The Length is measured in Feet and Half Feet, and, in some Places, to Quarters of Feet.

Then lay Half this Length from the upper Part, down towards the Butt-end; where, with a Piece of Chalk, make a Mark.

At that Mark, or nearer the Butt-end, if the Buyer think it to his Advantage, is taken the Breadth, in Inches and Half Inches.

If one Side be wainy, the Breadth is taken to the Middle of the Wain.

If both Sides are wainy, one Wain is measured, the other rejected; and either of them, as the Buyer thinks fit.

Having thus got the Length and Breadth; call the first long Division on A, and also on B, each an Unit. Then set the Index on B, against the Breadth in Inches on A, and against the Length in Feet on B, will stand the Content in Feet on A.

EXAMPLE.

Let there be a Plank, whose Length is 24 Foot and a Half, and Breadth 17 Inches and a Half; I demand the Content?

Set the Index on B, against 17 Inches and a Half on A, and then against 24 Foot and a Half on B, stands 35 and $\frac{3}{4}$ nearly on A; which is the Measure of the Plank required.

But when the Feet, in Length, on B falls beyond the End of Line A, then call the first 1 on A, a Ten, and then work as before taught.

EXAMPLE.

If a Plank be 45 Foot and a Half long, and 39 Inches broad, What is the Content?

Set the Index on B, against 39 on A, and 45 and a Half on B, will fall beyond the upper End of A.

Therefore set the Index on B, against 39 on A, taking in the first Part of A, because the first 1 on A is counted 10; and then, against 45 and a Half on B, will stand 148 on A, the Content required.

These are all the Varieties which happen in Plank-Measure.

But Notice may be taken, That from this Content must be subtracted as much Measure as will ballance all the visible Faults: And this is generally left to the Judgment of the Two Measurers, and generally done before the Contents are entered in the Accounts, or indeed, before you pass to another Plank.

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There are some Differences in the Customs of different Countries, tho', for the most Part, these are the most generally used.

The Customs generally used in taking the Dimensions of Timber, are not much different from those used for Plank.

For the whole Length is first taken in Feet and Halves, then the Middle found and chalk'd, where or nearer the Butt-end, as it is the Buyer's Advantage; the Stick is girth'd with a small Line, which is exactly quartered by twice folding; this Quarter is measured in Inches, Halves, and Quarters. And if the Tree's Bark is not peeled, as always happens in standing Timber; then from the foregoing Girth must be made an Allowance for the Bark, which is usually thus: For Trees girthing one Foot, allow one Inch, and so proportionably for all others. But for Beech, Elm, Ash, and such as are thin bark'd, then Allowance must be a small Matter less.

It is also to be observed, That, a Stick is not called Timber farther than it will hold Half a Foot Girth. Also, that if there be any considerable Arms which hold Half a Foot Girth; they are also called Timber, and measured as such.

CASE I.

Having thus taken the Length in Feet, &c. and Quarter Girths in Inches, &c. Set the Length on C, to the Index on the Girth Line, and then against the Girth on the Girth Line, is the solid Content on C.

EXAMPLE I.

Let a Tree be 24 Foot and a Half, long, and its Quarter Girth 17 Inches and one fourth; to find the solid Content:

Set 24 and a Half on C, against the Index on D, the Girth Line; and then against 17 and one fourth on

on the Girth Line, stands 50 three fourths on C, the solid Content of the Stick.

CASE II.

When, by the foregoing Directions, the Rule is set, and the Girth on the Girth Line is beyond the upper End of C; call the first 1 on C 10; and then work as before.

EXAMPLE II.

Let a Tree be 30 Inches Girth, and 40 Foot and a half long; to find the Solidity:

If you set 40 and a Half on C, against the Index on D, then 30 on D is beyond the upper End of C.

Therefore, calling the first 1 on C 10, set 40 and a Half on C, to the Index on the Girth Line D; and then, against 30 on D, will stand 253 on C, the Solidity required.

CASE III.

When the Girths on D fall short of the lower End of C; call the Middle 1 on C, a Unit; and then, all the figured Divisions, below the Middle 1, will be Tenth Parts of Feet; then work as above.

EXAMPLE III.

Let a Stick be 3 Foot long, and 6 Inches Girth; to find the solid Content:

Accounting the Middle 1 on C an Unit, set 3 on C, against the Index on D; and then, against 6 on C, stand 7 Tenths and a Half on C; the Solidity required.

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EXAMPLE IV.

Let a Stick be Seven Foot and a Half long; and Girth Four Inches: To find the Solidity.

N. B. Tho' this is not what is called Timber; yet since Alders and other Shrubs, used by Turners and others, are often measured, be they never so small; I thought it proper to insert some Examples of this Kind.

In the Three foregoing Cases, the Girths of the Sticks fell on the Girth Line C, without any arbitrary Alteration of the Values affixed to the Divisions; which fixed Values are abundantly sufficient for computing the Solidity of most Sticks usually to be met with, if the single Line C be advantageously broken. For, if a Person designs his Rule for the Measure of Timber only, that is, such as never girths less than Six Inches; then the Girth Line beginning at Six, will run to Sixty Inches: Above which, few Sticks will out-run. But if he designs to measure Alders, Shrubs and small Things, &c. often measured by Turners, Wheel-wrights, and other Artificers, using this small Stuff, the best Way is to have the Line C broke, and to begin at 1 and a Half, of 2, and end at 15 or 20, according to the Size of the Stuff they most deal in.

But that the Line, as usual or occasionally broken, may serve for the computing of common Timber, Timber extraordinary large, out-running the Girth Line, and also for Shrubs and small Twigs; it may not be amiss to consider the following Directions and Examples.

And in the first Place, we will enquire into the Use of the Rule in computing the Solidity of such large Sticks, as out-run the affixed Values of the Divisions on the Girth Line.

For which observe, That the Length of a Stick always to be found on the upper End of the Line C, is to be set to the Index; the Divisions on the Girth

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Line numbered 6, 7, 8, &c. are to be accounted 60, 70, 80, &c. and that, in estimating the Solidity of the Stick, the Divisions on C are to be estimated by 100 times the Value arbitrarily taken thereon by the Length: That is, if the upper Part of C be called Units in the Length; then, in the Solidity, the same upper Part shall be called Hundreds, and the lower Part Tens: In like Manner, if the upper Part of C be called Tens in the Length; then, in the Solidity, the upper Part shall be called Thousands, and the lower Part Hundreds.

E X A M P L E V.

Let there be a Stick, whose Length is Twenty-five Foot, and Girth Forty-six Inches; and let Forty-six be above the upper End of the Girth Line: To find the Solidity.

Then set Twenty five in the upper Part of C, against the Index on D; and then against (4 and 6 Tenths on C, which in this Case represents) 46 Inches, the Girth stands 367 Foot on the lower Part of D; estimated according to the preceding Directions.

E X A M P L E VI.

Let there be a Stick, whose Length is Four Foot, and Girth Forty-six Inches; and let Forty-six be above the upper End of the Girth Line: To find the Solidity.

Set 4 in the upper Part of C, against the Index on D; and then against the Girth 46, on the lower Part of D (which, in this Case, will be represented by the affixed Value, 4 and 6 Tenths) stands 59 fere on the lower Part of C, estimated according to the preceding Directions.

For very small Sticks, whose Girth falls below the beginning of the Girth Line C; observe, that the

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Length of the Stick always to be found on the lower Part of the Line C, is to be set to the Index ; the Divisions on the Girth Line numbered 10, 20, 30, &c. are to be accounted only 1, 2, 3, &c. and that estimating the Solidity of the Stick, the Divisions on C are to be estimated by the 100th Part of the Value arbitrarily taken thereon by the Length ; that is, If the lower Part of C be called Units in the Length, then in the Solidity, the same lower Part shall be called Hundredth Parts only ; and the upper End Tenth Parts. But if the lower End of C be called Tens in the Length, then, in the Solidity, shall the same lower Part be called Tenth Parts, and the upper End Units.

EXAMPLE VII.

Let a Stick be Fifteen Foot long, and let its Girth be Three Inches ; and let Three be below the lower Part of the Girth Line : To find the Solidity.

Set 15 Foot, taken in the lower End of C, to the Index on D ; and then against 3 (which, in this Case, will be represented by 30) in the upper Part of D, stands the Solidity 9 Tenths of a Foot, and a Quarter of another Tenth.

EXAMPLE VIII.

Let a Stick be Three Foot long, and let its Girth be Two Inches ; and let Two be below the lower Part of the Girth Line : To find the Solidity.

Set 3 Foot, taken in the lower End of C, to the Index on D ; and then against 2 (which, in this Case, will be represented by 20) in the upper Part of D, stands the Solidity, Eight Hundredth Parts of a solid Foot, and something more.

In those Places where the Custom allows the taking the Length to minute Parts of a Foot ; or when the

Length is less than One Foot: Take the Dimensions in Feet, and Decimal Parts of Feet.

Thus much for round Timber; but when Timber is hewn to that Form which is usually called square, tho' at the same Time there is most commonly Four Wanes; the Custom is to take the Length, and find the Middle in the same Manner, and with the same Allowances as were observed in round Timber; and then, in this Middle, either with a Pair of Calipers, or the Edges of Two Rules applied to the flat Faces, to take the Breadth and Depth of the Stick. Then, to add the Breadth and Depth together, and to use Half their Sum, as you before did the Quarter Girth of a round Stick.

EXAMPLE.

Let a Stick be Twenty-five Foot long, Fourteen Inches broad, and Twelve deep: To find the Solidity according to this Customary Method.

Because 14 and 12 give 26, whose Half is 13, set 25 on C against the Index on D; and then against 13 on D, stands almost 29 Foot and a Half solid.

And tho' this Custom makes the Stick something more than in Fact it is, by adding the Breadth and Depth together, and taking their Half for a Girth; yet, in a whole Tree, only hewn to a Square, the Difference is so very small, that the Custom may be admitted.

For in this Example it may appear by the Pen, That the Solidity thus is $29 \frac{12}{14}$ Foot; and the true Solidity, if the Stick be all of the same Bigness, and without Wanes, will be $29 \frac{2}{3}$, differing from the former only $\frac{1}{14}$, or $\frac{1}{8}$ of a Foot solid.

Never-

Nevertheless, in Sticks whose Breadth differs very much from the Depth; the Error is intolerable, and ought not to be admitted.

For, let there be a Stick 25 Foot long, 20 Inches broad, and 6 Inches deep; then, by the Customary Way of adding the Width and Depth together, the Solid will, as before, be $29\frac{1}{4}$ Foot; but the true Solidity will be only $20\frac{1}{4}$: And so the Error is $8\frac{3}{4}$ Foot, almost a third Part of the Stick.

For the ready Management of such Timbers, there may be placed on the other Leg of the Rule, another Slider; having the sliding Part and the upper fixed Line, exactly the same as in the former Leg; but on the other fixed Part, a double Line of the same Radius with the former, but broken and inverted. And as the Lines on the former Leg were distinguished by the Letters A, B, C, D, so the Lines on the latter are noted by the Letters E, F, G, H. And as the Divisions on the Lines A, B, C, were entirely arbitrary, so the Lines E, F, G, are also entirely arbitrary. And the Line H, which is inverted, and beginning at 1 and a Half, and running on to 150, the Values annexed to the Divisions, may be varied, or remain unvaried. But the Line E being direct, beginning at 1, and running on to a 100, the Values annex'd to the Divisions may be constant.

The Line H, I call the Depth Line, the Line G the Breadth Line; the Line E, I call the Length Line, and F the Content Line.

The Use is so short and so easy, that, in a few Words, and Two or Three Examples, it will be plain.

For, set the Breadth on G, against the Depth on H, and then, the Length on E, will stand against the solid Content on F.

Let the Stick be that of the last Example; where the Length was 25 Foot, Breadth 20 Inches, and Depth 6 Inches.

Set

Set the Breadth 20 on G, against 6 on H; and then, against 25 on E, will stand on F almost 21, the Solidity required.

And, to avoid Confusion, remember, That whatsoever is the Value of the Divisions on G, the same shall be the Value of the Divisions on F. That is, if the former Division on G be Units, and the latter Tens, then the former Division on F shall be Units, and the latter Tens. And if the former Divisions on G be Tens, and so the latter Hundreds; then the former on F shall be Tens, and the latter Hundreds.

If the Length on E falls beyond F, call the former Divisions on F, Tens, and the latter Hundreds.

If the Length on E falls short of F, call the former Divisions on E Tenth Parts, and the latter Units.

E X A M P L E.

Let a Stick hewn to unequal square Sides, have its Length 46 Foot, its Breadth 30 Inches, and its Depth 20 Inches, then, when 30 on G is set against 20 on H, 46 on E will fall beyond the Line F; therefore call the former Division on F Tens; and then set as before, and against 46 on E, will stand 191 $\frac{1}{3}$ on F, which is the solid Content.

The Shell, or Flitch of Timber is readily cast up by this Rule; for, take the Breadth on the flat Side in the Middle, and one Half the Depth in the Middle, and work with the Length and these, as tho' it were a square Stick, and you have the Solidity sufficiently near.

It is indeed true, That this is less than the true Solidity; but in regard of its Value it is thought enough.

Let there be a Flitch, whose Length is 30 Foot, Breadth 16 Inches, and Depth taken in the Middle 4 Inches. Set 16 upon G to 2 upon H, and against 30 on E, stands on F 8 Foot and one third, the Solidity required.

The

The Sawyers Measure is done by one Setting of this Rule.

For set the Number of Kerfs or Cuts on G, to the Breadth of the Boards on H, and against the Length of the Stick on E, stands on F the Hundreds of Feet Superficial.

E X A M P L E.

Let a Stick, whose Length is 30 Foot, Breadth 22 Inches, and Depth 20 Inches, be so cut, that each Board, with the Waste of the Saw, may be 2 Inches; that is, if it be cut parallel to the Breadth, we shall have Ten Boards, and so 9 Cuts or Kerfs, and the Breadth of each Board will be 22 Inches.

Set 9 on G against 22 on H, and then against 30 on E, stands 4.12 on F, that is, 4 Hundred and 12 Hundredth Parts of 120, or another Hundred.

Any Plank or Board, whose Value is expressed in Pence *per* Foot, may be cast up by this Rule at one Slip, without knowing the Measure of it.

E X A M P L E.

A Plank of Walnut-tree is sold at 2 s. 9 d. or 33 Pence *per* Foot, its Length is 30 Foot, its Breadth 26 Inches and a Half.

Set the Price in Pence, 33 on G, against 26 and a Half on H, and then against 30 on E, stands 182 on F, and a little more; that is 182 Shillings, or 9 Pounds and 2 Shillings.

It may be observed, That this sliding Rule is sufficiently exact, and very ready for Cubing Stone; provided, that the Two shorter Dimensions are taken in Inches, and the longer in Feet, and Decimal Parts of Feet.

Also, that it may be applied to the Cubing in Feet, any Solid in Form of a Parallelepipedon, whose Content doth not consist of more than 3 Places.

And

The

And if a Line be properly broken, and put on instead of H, it might be applied to Digging, &c.

Or if the Line H did slide as well as G; it might be applied to the measuring of all Sorts of Parallelipipedons, by one Setting of the Rule, whether the Answer be required in Feet, or Yards, or Rods, &c.

It remains to say something concerning the Estimate of the Measures of Timber standing.

And, First, We may observe, That, if we can get the Dimensions, the Manner of computing, after an Allowance for Bark, is that already laid down.

But since we cannot always get all the Dimensions, we must take those we can get at, and estimate the rest.

And, first, we may observe, That the Dimensions in a tapering Stick, which runs beyond Timber, may be had thus: Girth the Stick Breast high, to an 8th Part of this Girth, add Three Inches; and the Sum lessened by Allowance for Bark, will give the Girth in the Middle. And for the Length, measure from the Ground so high as the Tree runs Timber, and then work as before.

E X A M P L E.

Let the Girth Breast high, be 6 Foot, and Length 40 Foot; then, because the 8th Part of 6 Foot is 9 Inches, to this add 3 Inches, and the Sum is 12; from this deduct an Inch for Bark, and there will be left 11 Inches, which, with the Length 40 Foot, gives 31 Foot and a Half for the solid Content.

When the Taper Stick doch not out-run Timber at the Top, the whole Girth, at Top, shall be added to the whole Girth Breast high; and an 8th Part of this Sum shall be the Girth in the Middle; which

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which, after an Allowance for Bark, shall be the Girth to be used.

The usual Way of estimating the Height of the Tree, is, by applying to it a Ten or Twenty Foot Rod, and standing at a convenient Distance, and comparing the Rod with the Tree.

But the most certain Method is by the *Theodolite*, as now improved, thus: Measure from the Tree with a Ten-foot Rod 100 Foot, level the *Theodolite*, and direct the Telescope to the Top of the Tree; and then shall the Telescope cut on the Vertical Arch (if the Ground, from the Tree to the Instrument, be nearly upon a Level) a certain Number of Feet; to which, if you add the Height of the Telescope, you will have the Height of the Tree.

But if the Ground, from the Tree to the Instrument, be not quite Level; then direct the Telescope to the Top of the Tree, and note the Feet cut by the Telescope; and then direct the Telescope to the Bottom of the Tree, and note the Feet there cut.

And if one of these Numbers of Feet be above the Level, and the other below, then their Sum is the Height of the Tree; but if both are above, or both below, then the lesser taken from the greater, will give the Height of the Tree, without any other Calculation.

When the Ground, from the Tree to the Instrument, is very steep, take, with your off-set Staff, or Five-foot Rod, the Height of the Instrument above the Ground, and at the same Height on the Tree above the Ground the Tree stands on, make a Mark. Direct the Telescope to this Mark, and it will cut on the Vertical Arch among the second Divisions of Reduction, a Number of Feet, which shall give the proper Distance to plant the Instrument from the Tree; or, which is the same Thing, it shall give a Length on the Ascent, which answers to 100 Foot measured Horizontally.

The Instrument being planted at this Distance, work as before, and you will have the Height of the Tree correct.

N

Having

Having mentioned this Vertical Arch, and its Use in taking Heights; I will now proceed to shew its farther Uses in surveying Land.

If, in coming up an Ascent, or going down a Descent, as soon as the Instrument is set for observing the Angle; you look on the Vertical Arch among the Division of Reductions, you will find how many Links, in every Chain's Length, this Hypothensal Line is to be shortened, in order to get the Horizontal Line, which ought to be laid down in your Plane, and must be entered in your Book.

And these Divisions of Reduction are concentric with the Divisions of Altitude, and also with the Divisions of Degrees; and the second Divisions of Reduction.

Lastly, If the Distance from the Tree to the Instrument be confined; then multiply the Horizontal Distance in Feet, by the Feet given by the Instrument, and from the Product, towards the Right-hand, cut of Two Figures, and those to the Left, will be the Height of the Tree in Feet.



SECT. VIII.

Of Water-Levelling, or the Conducting of Water.

THE first Thing necessary to this Purpose, is the adjusting of the Level, which may be performed several Ways: This that follows is very easy and natural.

Chuse some Ground which is not above 4 or 5 Foot, out of the Level for the Distance of 8 or 10 Chains Length, and suppose it be A B, (Fig. 17)

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and find the Middle between A and B, which suppose to be C; plant the Instrument at C, direct the Tube to a Station Staff, held up at A, and elevate or depress the Tube, till the Bubble is exactly in the Middle of the Divisions; then by Signals direct your Assistant at A, to raise or depress the Vane, sliding on the Station Staff, till the Horizontal Hair in the Glass, cuts the Middle of that Vane; then see how many Feet, Inches, and Parts, are cut by the upper Part of the Vane; which suppose to be 3 Foot 4 Inches and 6 Tenths.

In like manner direct to the other Staff at B, and suppose the upper Edge of that Vane, to cut at the Height of 6 Foot 5 Inches and 2 Tenths; then will these Two Vanes be on a Level.

From 6 Foot 5¹/₂ Inches subtract 3 Foot 4¹/₆ Inches, and reserve the Remainder 3 Foot 0¹/₆ Inches.

Now, remove the Instrument as close to the higher Station Staff as you can; so that the Middle of the Telescope may almost touch it. Then bring the Telescope as near to a Level as the Judgment of the Eye will direct.

Measure the Feet, Inches, and Parts, that are even with the Top, and also with the Bottom; suppose them to be 4 Foot 10¹/₅ Inches, and 5 Foot 0¹/₃ Inches; then Half the Sum of these Heights, 4 Foot 11¹/₄ Inches, is the Height of the Center of the Glass; and to this, add Half the Breadth of the Vane, which suppose to be 1 Inch and 5 Tenths, and to the Sum 5 Foot 0¹/₉ Inches, add the preceding Remainder 3 Foot 0¹/₆ Inches; then let the Person at B move his Vane, till the upper Edge cut 8 Foot 1¹/₅ Inches, the Sum of the preceding Numbers.

Now, so elevate or depress the Hair or the Bubble, till the Hair cut the Middle of the Vane at B, and at the same Time, the Bubble stands in the Middle of the Divisions; and then will the Instrument be duly adjusted.

If you have a Mind to be curious, repeat the Operation; but when you place the Instrument at C, turn

the Tube at right Angles to the Line A B, and there set it level; then proceed with the Repetition of the Work. Only observe to cross-level it in this Adjustment; and in all future Uses whatsoever.

Or the Level may be adjusted thus: As before, first plant the Instrument in the Middle between A and B, (Fig. 18) and observe the Heights on the Station Staves, which suppose to be as above; and consequently their Difference, as before, is 3 Foot 0.6 Inches. Now measure from C towards the highest Ground A, some Distance that comes almost to A; suppose 4 Chains to D, then will D B be 9 Chains, and D A be 1 Chain: Then plant the Instrument at D, direct the Telescope to A, and, setting the Bubble to the Middle of the Division, direct your Assistant to move the Vane, till the Hair cuts the Middle of it; and note down the Feet, Inches, and Parts cut by the upper Edge of the Vane; which suppose to be 3 Foot 8.4 Inches: To this add the Difference 3 Foot 0.6 Inches, and the Sum 6 Foot 9 Inches reserve.

Now direct the Telescope to the Staff at B, level it, and direct your Assistant to move the Vane, till the Hair cuts the Middle of the Vane; and then, if the upper Edge of the Vane cuts the foregoing Sum 6 Foot 9 Inches, the Hair and Bubble are truly adjusted. But if not, say, as B D wanting A D, is to the Difference between the Numbers cut by the upper Edge of the Vane, and the Number 6 Foot 9 Inches; so is the Distance A D to a Number, which added to that cut by the Vane, when less than 6 Foot 9; and subtracted from the Number cut by the Vane, when it is greater than 6 Foot 9; will give a Number, to which let the Assistant affix the Vane; then, so elevate or depress the Hair or the Bubble, till the Hair cuts the Middle of the Vane at B, and the Bubble stands in the Middle of the Divisions; for then will the Level be adjusted. The Operation may be again repeated, and at every Station Cross-levell'd, which will confirm the former Adjustment.

After

After the Instrument is duly adjusted, you may proceed to use it. Let the Example be this annexed, (Fig. 19) where A every where represents the Level, and B the Station Staves; and suppose the Rout be made from a to e; first plant the Instrument between the Station Staves, between a and b: At A direct the Level to a B, bring the Bubble to the Middle of the Divisions, and instruct your Assistant so to place the Vane, that the Hair in the Telescope cuts the Middle of the Vane; then in a Book divided into Two Columns, the one intituled *Back Sight*, the other *Fore Sight*, enter the Feet, Inches, and Parts cut by the upper Edge of the Vane at a B, in the Column intituled *Back Sight*.

Then look towards the other Staff b B, bring the Bubble to the Middle of the Divisions, and direct your Assistant to place the Vane so, that the Hair cuts the Middle of the Vane; then enter the Feet, Inches, and Parts cut by the upper Edge of the Vane, in the Column of *Fore-Sights*.

Now, plant the Instrument at A², still keeping the Staff B b exactly in the same Place, and carry the Staff a B forwards to the Place c B; now look back to the Staff b B, and enter the Numbers cut by the Vane there, under the Title *Back Sight*; then look forwards to c B, and enter the Observation under the Title *Fore-Sight*. Do the like when the Instrument is planted at A³, A⁴, &c. always taking Care to keep the Staff in the same, when you look'd at it for a *Fore Sight*, till you have also taken with it a *Back-Sight*.

Having finished your Level; add up the Column of *Back-Sights* into one Sum, and the Column of *Fore-Sights* also into one Sum; and the Difference between these Sums is the Ascent or Descent required. And if the Sum of the *Fore-Sights* is greater than the Sum of the *Back-Sights*, then e is lower than a; but if the Sum of the *Fore-Sights* is less than the Sum of the *Back-Sights*, e is higher than a. For Example sake, let the Numbers be as in the following Table,

Back

After

Back Sights.

F. I. P.

3 . 7 L 5
4 . 6 L 8
6 . 0 L 2
9 . 5 L 4
1 . 0 L 7

24 . 8 L 2

Fore Sights.

F. I. P.

6 . 4 L 5
8 . 3 L 2
5 . 4 L 7
8 . 7 L 8
9 . 4 L 8

38 . 1 L 0

24 . 8 L 2

13 . 4 L 8

Hence the Descent

13 . 4 L 8

Now follow some Observations well worth Notice.

I. If the Sum of the Distances in taking the *Back Sights*, is equal to the Sum of the Distances in taking the *Fore Sights*, all the Minute Errors of the Instrument will mutually ballance and destroy each other.

II. And if the Distances thus taken are short, the Curvature of the Earth may be rejected. For, if the Distance from the Instrument be every where about 100 Yards, all the Curvatures in a Mile's Work, will be less than Half an Inch.

III. If the Distances from the Instrument to the hindermost Staff, be every where equal to the Distance

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stance from the Instrument to the corresponding Staff; the Curvature of the Earth, and the Minute Errors of the Instrument will both be destroyed.

IV. If the Distances of the Instrument from the Staves, be very unequal and very long, the Curvatures must be accounted for, and the Distances, in order thereto, must be measured, either by Pacing, by a Chain, or a Wheel.

V. For the more ready allowing for the Curvature, you may observe, That the Curvature for one Mile, taken at one Observation, is extremely near to 8 Inches. And at all other Distances, it is as the Square of one Mile is to 8 Inches, so is the Square of any other Distance to the Allowance for the Curvature; and that this Curvature is always to be subtracted from the Numbers taken of the Station Staff: Or if the Distance be less than a Mile, and taken by the Four Pole Chain; square the Chains, cut off 2 Places to the Right-hand, and divide those to the Left by 8, and the Quotient shews the Inches and Parts of Inches to be allowed for the Curvature. Suppose the Distance be 30 Chains; then the Square of 30, that is, 900, when 2 Places are cut off, gives 9, which divided by 8, gives 1 Inch and 125 Thousandth Parts of an Inch.

VI. If these Distances were taken by Pacing, accounting 25 to the Chain, the Curvature may be found thus; Square the Paces, and double it, cut off 6 Places to the Left-hand, and those to the Right are the Inches of Curvature: So, if the Paces were 900, then from 810000 multiplied by 2, that is, 1620000, cut off 6 Figures, and you have 162, the Curvature to be allowed. To save the Trouble of continual Calculations you may use the following Table.

Di-

Differences in Chains.	Allowances, in Inches, and Parts.
5	0 L 03
10	0 L 12
15	0 L 23
20	0 L 50
25	0 L 78
30	1 L 12
35	1 L 53
40	2 L 00
45	2 L 28
50	3 L 12
55	3 L 78
60	4 L 50
65	5 L 31
70	6 L 12
75	7 L 03
80	8 L 00
85	7 L 03
90	10 L 12
95	11 L 28
100	12 L 50

VII. Therefore it appears, That the best Method to take a Level, is to measure the several Distances from the Instrument to the Back and Forward Station Staffs; and enter them in the Field Book, according to the Titles of their several Columns, as here below; and before you ballance the whole Level, to make the Sum of the Distances of the *Fore-Sights*, equal to the Sum of Distances of the *Backs*; and to account for the Curvature of the Earth, which may be done at Home, when you are about to sum up the Heights.

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Fig. 19

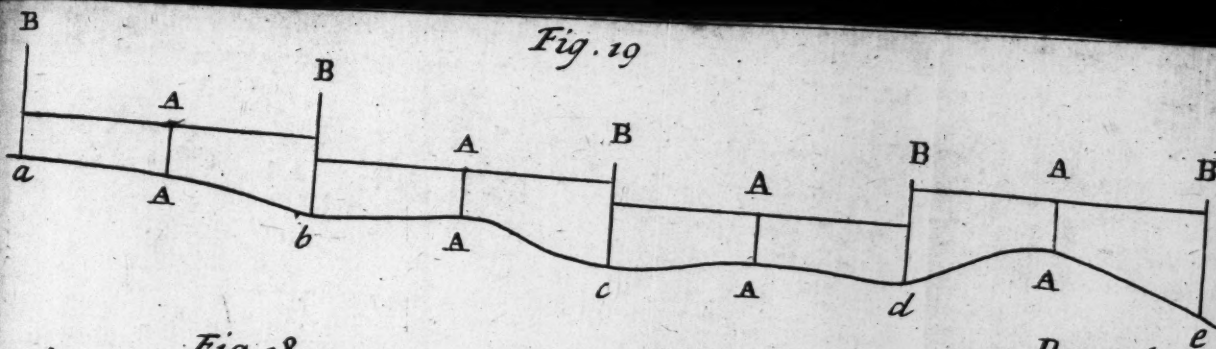


Fig. 18.

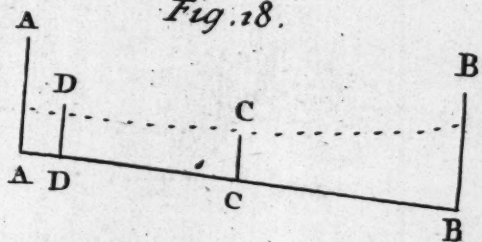
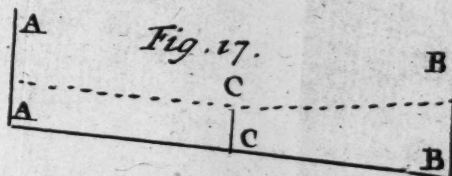


Fig. 17.



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Lastly, Tho' hitherto we have considered the Level with one Telescope only, the same Observations may be applied to a Level, with a double Telescope; and I would advise those who use the double Telescope, at every Station to turn that End of the Telescope towards the Spring, which, before was the contrary Way.

SECT.



S E C T. IX.

Of COLOURS.

IT is not worth while to speak of the Preparation of Colours, because they may be had ready prepared, at almost every Colour-Shop, and Fan-Painters, &c. Nor to mention but as many as are necessary and most fit for the Surveyor. Those, I judge the best, which are most transparent, and most easily transportable.

And of Portability, I think Liquids improper; therefore would rather chuse those Colours, which, before tempered, are dry; whether in Powder or in Lumps: And such as require no other Liquid to mix with them (than what is to be had every where) viz. fair Water.

For *Gum Water*, with which many Colours are mix'd, is made by barely steeping *Gum Arabick* in fair Water.

Carmine, a Powder, mix'd with *Gum Water*, is a beautiful Red; may be shaded with some of the same, mix'd stronger; or with any reddish Brown, or any sadder Red.

Ultramine, a Powder, mix'd with *Gum Water*, is a most valuable Blue, fit to shew Ponds, Lakes, Rivers, &c. it may be shaded with *Indigo Corns* ground with fair Water on a white Tyle, by the Pressure of a Knife's Point, and then mix'd with *Gum Water*.

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Red Chalk, a Lump, sometimes called *French Chalk*, ground by rubbing it on a Tile with fair Water, and afterward mix'd with *Gum Water*; slightly laid on, is proper to represent Roads and Pits; and is shaded by it self, more strongly mix'd.

Sap green, steeped in Water of its self, a good Green to colour Trees.

Verdegreece, in Lumps, dissolved in Vinegar, or in Water, makes a greenish Blue, or Sea-Colour, very transparent.

Gumbooge, in Lumps, steeped in fair Water, produces a beautiful and transparent Yellow.

Yellow Berries, steep'd in fair Water, a Yellow.

Verdegreece dissolved, mix'd with *Gumbooge*, or Yellow-berries, in different Proportions, produces different Greens, inclining either to the Blue or Yellow, according to the Quantities of either used.

All Colours are shaded by others of the same Sort, but more sad.

I shall not trifle, in telling how these Colours may be compounded, or laid on, they being to be known by Experience much better than by many Words. Nevertheless, in my Judgment, a Draught looks best, when the Stains are only visible.





S E C T. X.

*The Surveying of Shoals and Sands, by
Help of the New THEODOLITE.*

T H E R E are Three Methods whereby this may be performed; for the Observations may be made either on the Water or on the Land. Those made on the Water, are of Two Kinds, One by the Log-line and Compass (as in plain Sailing) measuring the Course and Distance round the Sand; and then to be plotted as a large Wood, or any Enclosure taken by the Circumferentor.

This Method I omit for Two Reasons; First, because it is to be deduced from the Writers of Navigation; and, Secondly, because the Distances thus measured are liable to the Errors of Currents, which generally attend Shoals or Sands, which are always near to the Shoar.

The Second Method, where there are no Distances, to be measured on the Water, tho' still there is one Inconvenience, common also to the former, because the Bearings or Observations are to be taken on that unstable Element, (an Error scarce mentioned, by our practical Artists) I shall briefly hint at; and so rather chuse a Third, which is liable to neither of these Imperfections.

Let (in Fig. 20) a Boat be manned out with a Signal Flag, a Log and Line, Lead and Line, and to observe the Bearings of any Land Mark, a Compass with Sights;

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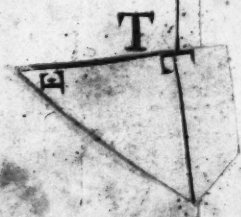
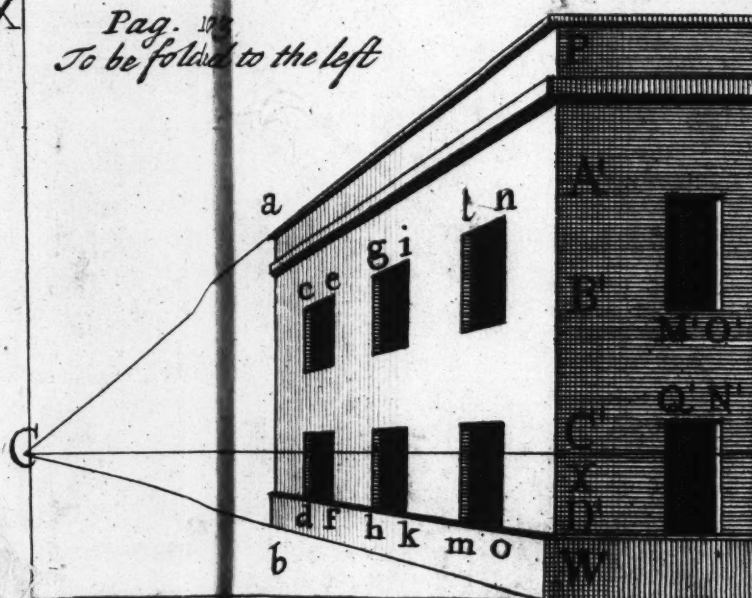
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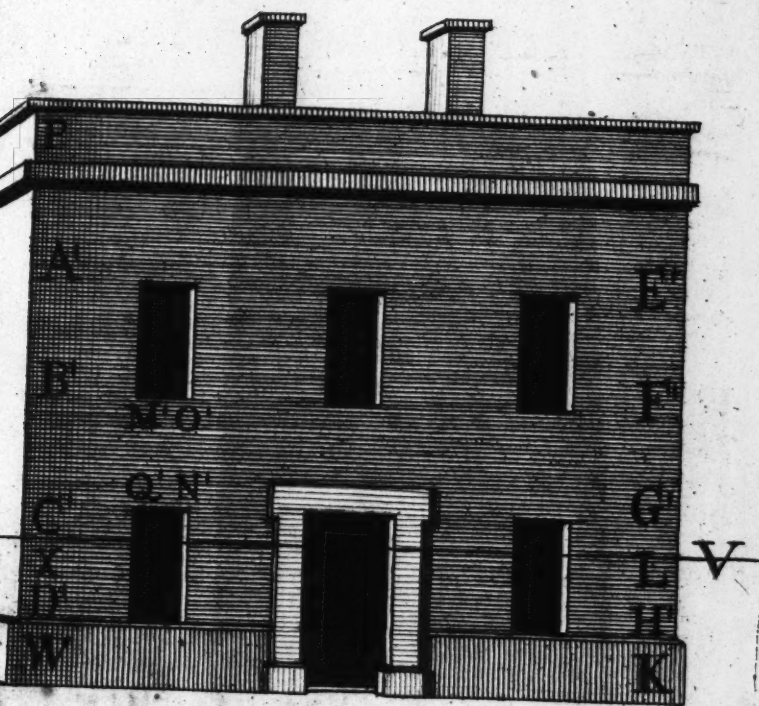
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Fig. 21

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Let Two or more Places, as A, B, C, on the Shoar, from whence the Boat may be seen on the several Parts of this Shoal.

One of the Boat's Crew is to sound till he finds himself on the Edge of the Sand, by the Depth of Water, and then to come to an Anchor; which he is to signify to Two Persons on the Shoar, at B and C, by his Signal. And then they, from those known Land Marks, B and C, the Observers, are to take the Bearings of the Boat, and to register their Observations; which, when done, they are to signify to the Crew by waving a Flag, or by some other Signal.

And in the mean Time, to prevent Mistakes, let the Crew take the Bearings of each of these Land-Marks: Then weigh Anchor, which suppose at D.

Then by Sounding, proceed to E, and make like Observations. And so at E, F, G, &c. till you have surrounded your Sand.

And if in this Process, you are about to lose the Sight of one of your Land Marks, suppose C, let your Assistance at C, who, at that Time, will also be about to lose the Sight of the Boat by Signals (before hand agreed on) remove to some other Objects, before-hand agreed on, suppose to H; and then to proceed as before.

Lastly, If the Sand runs so far out to Sea, that the Object cannot be seen by the Boat, nor the Boat by the Observer on Shoar; there may be Rockets fired by the Boats Crew, and also the Observers on Shoar in the Night, by which those Bearings may be taken almost at as great a Distance as the Light can be seen. For supposing they rise but one Half Mile, and one Quarter of a Mile above the apparent Horizon, its Stay will be about 9 Seconds, and its Distance for this Quarter of a Mile will be visible about 44 Miles.

But Rockets rise much higher, and then the Distances are much greater, whereby they are visible.

Or Two Boats may lie at Anchor instead of the Land Marks, and then you may work as before.

Lastly,

Lastly, Since the Land Mark B and C are fixed, their Position may be laid down in the Draught, as in common Surveying, by plotting the Distance between B and C. And then, by plotting the Line B D, and the Line D C, according to their Position, their common Interfection, will give the Point D. And in like Manner, E, F, G, &c. may be plotted; and so the Shoal: And this from the Bearings taken at B and C.

If this be a standing Lake, environned by Bogs, not to be walked on; the Observations at D, E, F, &c. by taking their Opposites, may suffice to plot the same from the Land Marks A, B, C, &c. as well as those taken on the Land. Or, indeed, by the Course and Distance, as in Navigation, if the Water be smooth and without a Current.

In Sea Shoals, it is convenient to note at each Observation the Depth of Water found by the Lead, and the Drift and setting of the Current by the Log and Compass, while the Boat is at an Anchor, which may be done with Ease and Expedition enough. For while the Boat rides at an Anchor, her Stern points out the Setting of the Current, and the Log and Glass will measure its Drift.

And these ought to be noted on the Draught, which may be thus:

The Currents may be shewn by drawing a Dart pointing out its Setting, and its Drift by the Roman Capital Letters, and the Depth of Water by the small Figures.

All Nocturnal Observations ought to be several Times repeated.



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S E C T. XI.

*The Use of the Theodolite, in drawing the
Perspective Appearance of any Building
without Measuring.*

THIS will admit of some Variety; for either the Picture is supposed to be parallel to one of the Fronts of the Module or Building; or else oblique to both; and then is either in a Position assigned, or in a Position taken at Pleasure.

First, suppose the Picture parallel to one of the Fronts, then plant the Instrument and a Staff at any equal Distances from the Front, suppose 5, 10, or 15 Foot; then direct the Telescope to the Staff, and the Needle will point out the Bearing of that Front: To this add or subtract 90 Degrees, you will have the directing Number.

Now plant your Instrument at the Place, whence the original Building is to be viewed. Bring the Index to the Beginning of the Divisions, and turn the whole Instrument about, till the Needle Points at the directing Number; and then screw it fast. Bring the Telescope to the Beginning Divisions in the Vertical Arch, and level the whole Instrument: So will the Instrument be duly seated and rectified for Observation.

In order to get easily a due Knowledge of Perspective in general, and particularly of the Use of this Instrument in drawing, turn to Figure 21, and raise up the Draught P Q perpendicular to the Plane of the Leaf upon the Line W Q, and lift up the Plate A Y W, till it is perpendicular to both the
Plane

Plane of the Leaf, and also to the Draught P Q; then raise the Draught A B W till it coincides with A Y W, and consequently will be perpendicular to the Plane of the Leaf, and also to the Draught P Q; so will the Two Draughts A W, P Q, be the Two Fronts of the Module, represented to the Eye. Lift up the Draught a V till it is perpendicular to the Plane of the Leaf, and it will be the Picture designed to be drawn; and it will co-incide with P Q, the Front of the Module. T is the Point on the Ground whence the Building is to be seen. Lift up E T, till the Point E is perpendicularly over the Point T: And E is the Eye of the Spectator, or the Centre of the Telescope. Now if you conceive strait Lines drawn from the Eye at E, to the several Points A, B, C, D, &c. in the Module, they will meet the Picture in the Points a, b, c, d, &c. which are therefore the true Appearances of those original Points A, B, C, D, and a Line drawn from a to b, will be the true Appearance of A B; and so of all other Lines: For the Rays of Light come to the Eye from the Picture in the very self same Direction that they would have come from the original Module. Thus much by Way of Introduction.

Now, in Order to draw the Picture; Assign on your drawing Board any Point C, at Pleasure, for the Centre of the Picture; and draw C V the horizontal Line, and perpendicular to it, the Vertical Line C S; from these Two Lines, all the Parts of the Building are to be laid down by their apparent Distances from them.

N. B. By the Centre of the Picture, I mean that Point, whence, a Line drawn to the Eye is perpendicular to the Plane of the Picture. The Horizontal Line is that which passes thro' the Center, and is parallel to the Horizon; and therefore is the common Intersection of the Picture, with the Plane of the Ocular Horizon.

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The principal Line in these Draughts is, that Coin, or that Angle which is common to both, the Picture and the Module; and consequently every where proportional to the Building it self. And is the first Line to be laid down and divided; which may be done thus. Let the Example be as in the preceding Scheme.

Direct the Telescope to the Point P in the Building, and you will find the Index on the Horizontal Plate of the Instrument cut 32 Foot and a Half, and on the Vertical one 25 Foot; lay the latter, above the Horizontal Line C V, and perpendicular to it, from C to X; and the former from C to x. Then, by Help of the Square, draw x P; X P perpendicular to C V, C S, whence the perspective Appearance of the Point P is found.

In like Manner, may be found the perspective Appearance of any Point whatsoever; whether it be coincident to both the Module and Picture or not.

Depress the Telescope to W, in the Building, and (in this Example) it will cut on the Vertical Arch 9 Foot; which, because you look downwards, lay from x downwards to W in the Picture, and so you have the true Appearance of W. And consequently if you draw P W in the Picture, you have the true Appearance of the Line P W in the Building.

If you elevate the Telescope to A', in the Building, it will cut on the Vertical Arch 15 Foot; which laid from x to A' in the Picture upwards, because the Point is above the Horizontal Line C V, will give the Representative of that Point in the Picture. And so every of the Points B', C', D', &c. may be laid down in the Picture.

Direct the Telescope to K' in the Building, and you will find on the Horizontal Arch, that the Index cuts 69 Foot and a Half; which laid from C to L', gives in the Picture, the Representation of the Point L'.

Thro' L', draw E' L' K' perpendicular to C V, and A' E', B' F', C' G', &c. parallel to it, thro' the Points A' B' C', &c. and so the Coins E K, and the Tops and Bottoms of the Doors and Windows may be limited in Respect of their Heights.

Direct the Telescope to M', and it will cut on the Horizontal Arch 38 Foot and a Half; which lay from

P

C to

C to Q, and it will determine the Appearance of Q. In like Manner lay down N'; and the Jaumbs of the Windows Q' N', M' O', will be laid down. And in like Manner may the other Windows, Doors, &c. be drawn.

For the returned Front a W, draw PC, WC, A C, B C, C C, D C, &c. and they will limit the Heights of the Parapets, Facia's, Windows, &c.

Direct the Telescope to b, d, f, h, &c. and it will cut on the Horizontal Plate 16 Foot, 17 Foot and a Half, 19 Foot and one Third, &c. - - - -, which laid from the Vertical Line X S, will give the Breadths, representing the Pierres and Windows.

The same may be done for the Chimneys and their Returns; or for any other Lines, Breaks, &c. And so the several Parts of the perspective Appearance of a Building may be drawn without Measuring.

That this Compendium of Perspective may be compleat; it may not be amiss to lay down the necessary *Theorems* in the most general Manner possible; and herein I shall use those Terms which Dr. *Brook Taylor* hath thought fit to mention, they being more Comprehensive than such as are used by the other Writers on this Subject.

Theor. I. All Lines originally (or in the Module) parallel to one another, and to the Picture; will be represented by Parallels on the Picture.

Theor. II. All Lines parallel in the Module or Building which are perpendicular to the Picture, will, if continued, run to the Center of the Picture. Tho' these Parallels be or be not all in the same Plane.

Theor. III. All Lines in the Module or Building, perpendicular to the Plane of the Horizon will be in the Picture, perpendicular to the Horizontal Line. And these Three *Theorems* are sufficiently visible in the preceeding Example.

Theor. IV. All Lines, in the Module or Building, parallel to one another, and to the Plane of the Horizon, but oblique to the Picture (as in the following Example) will meet in some one Point in the Horizontal Line C V. This Point is (by Dr. *Taylor*) called the vanishing Point of these Parallels, and is by him thus found.

From

From T, the Point representing the Place from whence the Building is to be viewed, draw a Line parallel to the Parallels; and where it meets the Ground-Line S T, raise a Perpendicular R Y, and you have the vanishing Point required.

Theor. V. All Lines which are parallel to one another, but oblique to the Picture, and not parallel to the Plane of the Horizon, will be represented by Lines meeting in a vanishing Point, found by the Intersection of the Picture and a Line, drawn from the Eye parallel to those Parallels. But this vanishing Point will not be in the Horizontal Line, but either above it or below it.

Theor. VI. The Shadows of all parallel Lines made by the Intersection of the Sun's Rays; will, on the Ground, be parallel; and consequently in the Picture, either be parallel, as in *Theorem I.* or else meet at a Point in the Horizontal Line, as in *Theor. II.*

Now, as in the former Example, the Center of the Picture being determined, the Parallels which were perpendicular to it, and also parallel to the Plane of the Horizon, were, by the Help thereof, easily drawn; so in this Example following, since the vanishing Points are of no less Use to draw all Parallels; I shall shew one general Law, without any Exceptions, for this Purpose; not after the Manner of Dr. Taylor, but by this *Theodolite*, which, as well as all Sorts of Mathematical Instruments, according to the latest Improvements, is made by THO. HEATH, at the *Hercules and Globe*, next Door to the *Fountain Tavern* in the *Strand*.

Let the Example be that of *Fig. 22*, where, as before, raise the Draughts P Q, A Y W, A B W; and you have the Module represented to the Eye (A W Y coinciding with A B W) Raise a Q perpendicular to the Plane of the Leaf; and it is the Plane of the Picture designed to be drawn; but it is oblique to each Front of the Module: And the Coin P W, is the only Part of the Module or Building, which coincides with the Picture. Raise up T E as in the former Example. And E represents the Eye beholding the Building or Picture. Plant the Instrument and a Staff in the Line S W, which is the Ground Line of the Picture, or else at equal Distances from it, that is, parallel to it. And find, as in the foregoing Example, the directing Number.

Plant the Instrument at your designed Station T; and rectify it as in the preceding Example. Assume the

the Center C, on the drawing Board, draw CV, CK, as before.

Then lay down PW, and its several Divisions A, B, &c. and the Two Points a, b, as in the former Example. Draw Pa, and Wb, and produce them till they meet: So shall their Intersection V be the vanishing Point sought.

Use this Point V as you did the Center of the Picture in the preceding Example; and then go on to draw the Front a W as before.

In like Manner find the vanishing Point Y; and proceed to draw the Front PQ.

As to the Position of the Picture, some Persons will have it parallel to a Front, others parallel to the Diagonal of the Plane; others chuse rather that Position to which a Line drawn from the Eye to the common Coin PW, may be perpendicular to the Plane of the Picture.

And in this latter, there is no Occasion for the directing Number, or the Bearing of any Front: For take T the Station at Pleasure; bring the Index to the Beginning of the Degrees on the Horizontal Plate, and turn the whole Instrument about till you see thro' the Telescope the Coin PW, and screw it fast, and level it; And proceed in all Respects as in the last Example.



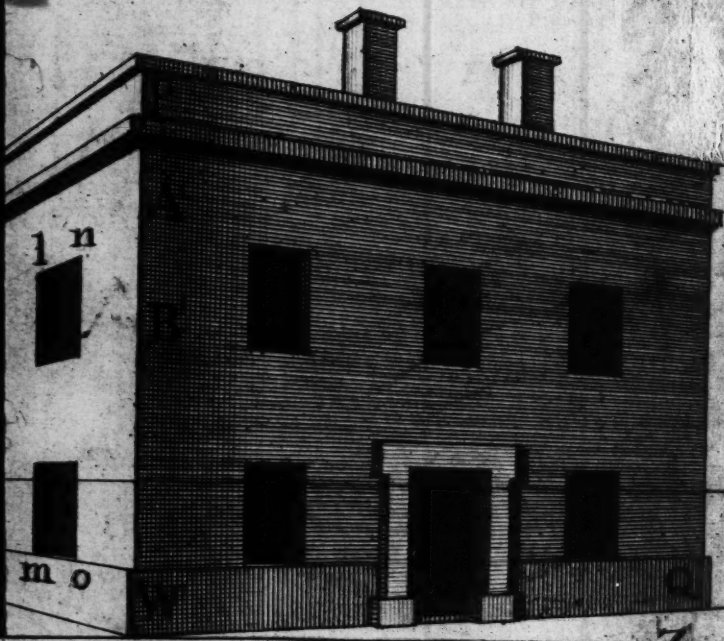
SECT. XII.

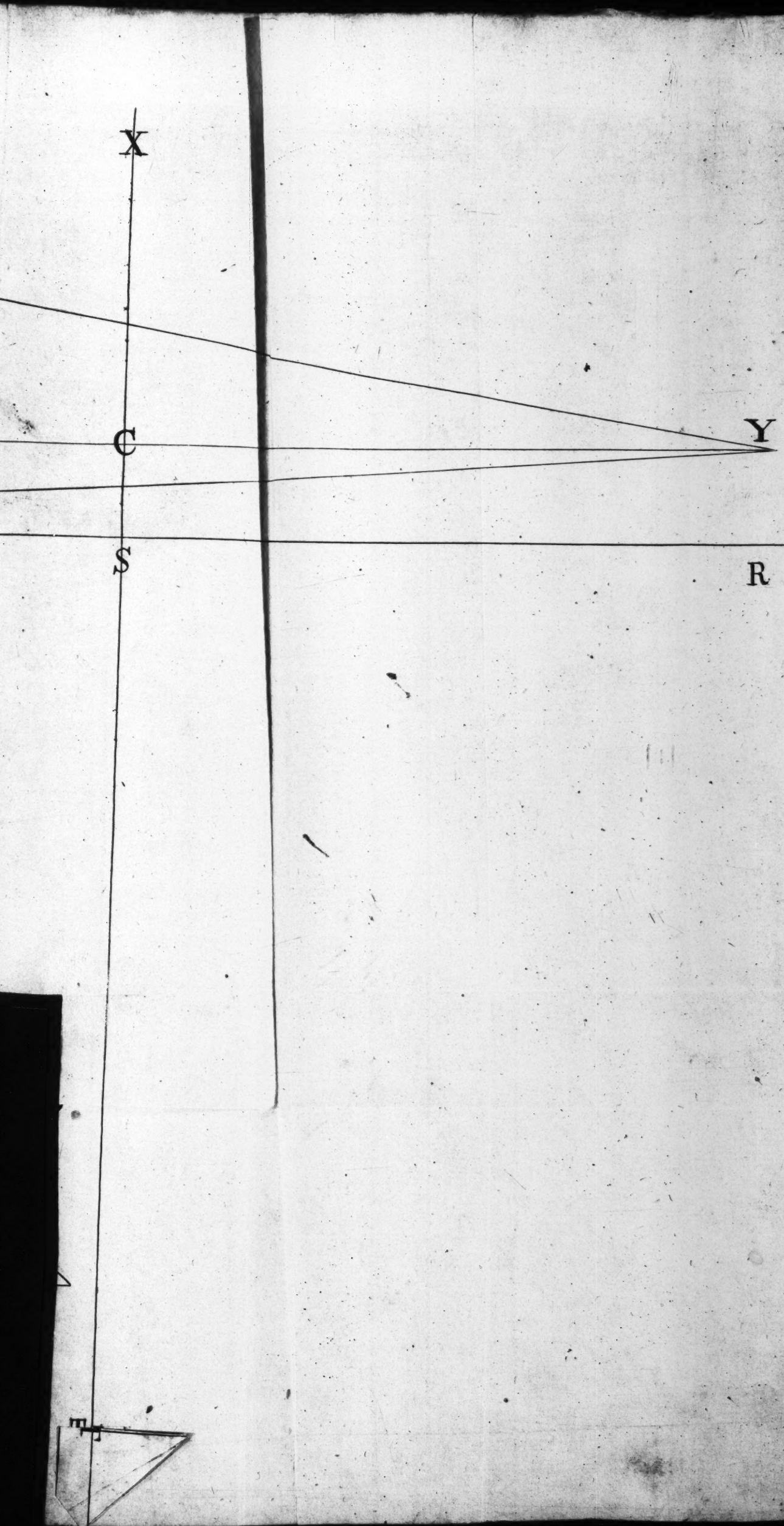
The Use of the Universal Dial, and the Variation of the Compass.

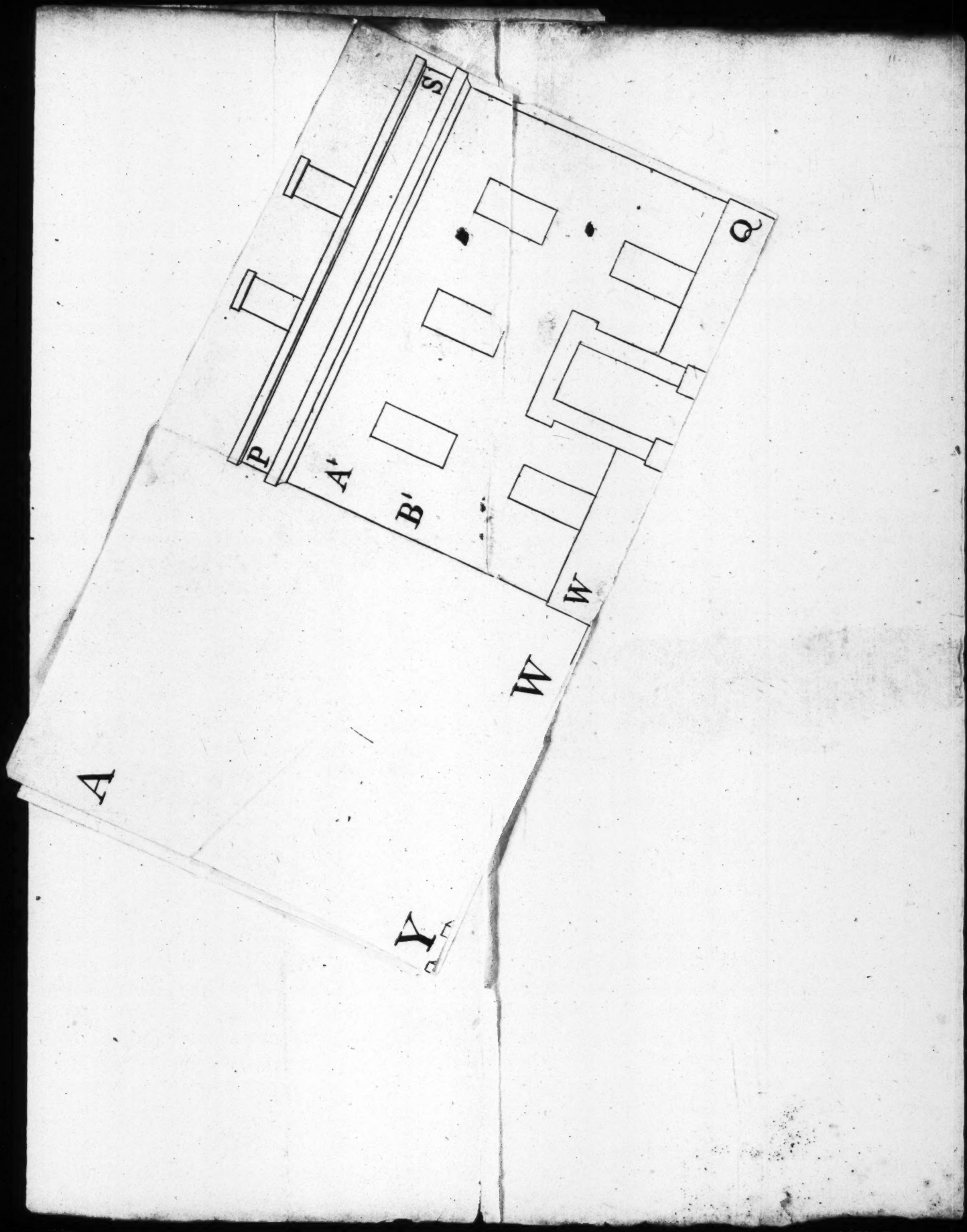
IT hath been supposed, That a Needle, playing freely, which hath had a strong Touch from the Loadstone, points exactly North and South. But by numberless Experiments it hath been proved, That the Needle doth not point exactly North and South, in any Places of the World, but such as lie on one particular Line, which is therefore called *The Line of no Variation*; And that this Line changes its Situation by a slow Motion, from East to West. It now passes from

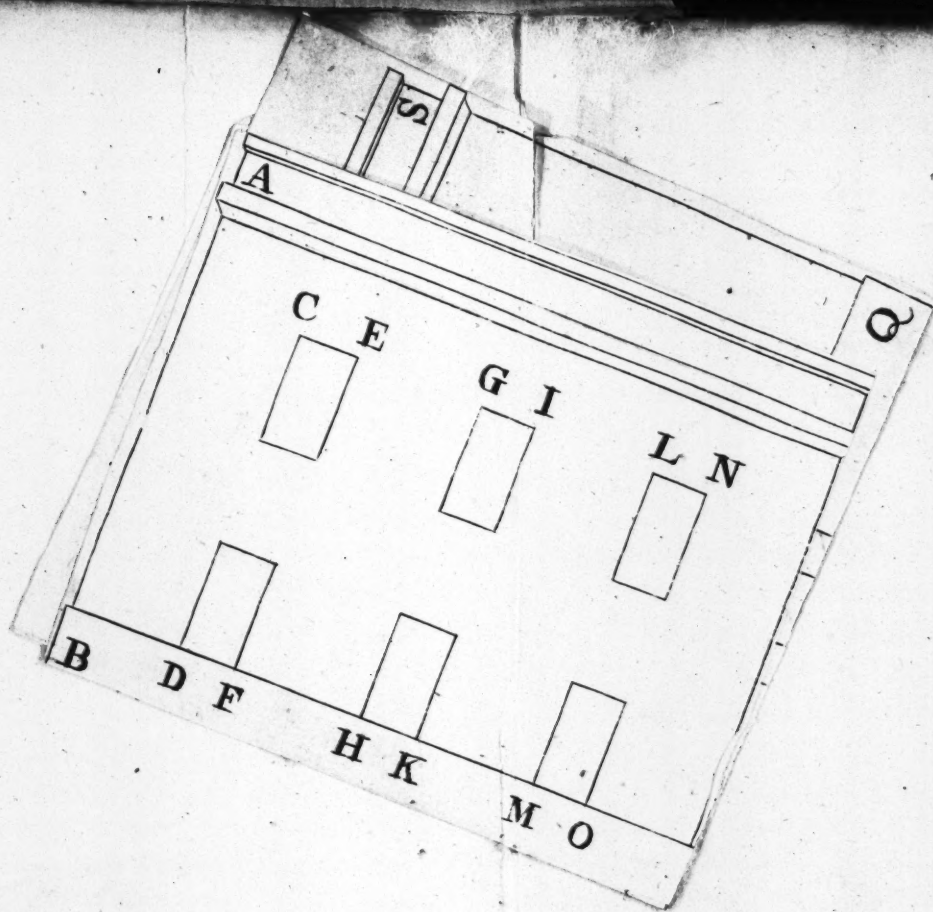
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Fig. 22









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from the Westward of the *Cape of Good Hope*, to the *West Indies*. And the Variation of the Needle in all other Places is known constantly to alter by a slow Change. In *England* that End of the Needle which hath been supposed to point full North, deviates from it now about 14 Degrees to the Westward; and is still, and also will for many Years continue to increase, even till it arrive at its *Maximum*; and then will decrease till it vanishes, and then change to the Eastward, as it formerly was; and by an oscillatory Change will so continue to alter.

This Variation of the Needle would no ways hinder the Exactness of the Survey, if it was constant; nor is the Alteration of the Variation capable of making any sensible Error in a Survey that is performed in a Space of Time not exceeding Four or Five Years.

But if the Quantity of the Variation be not known, and consequently not allowed for, the North Point of the Compass, which the Surveyor draws on his Map, will err as much as that Variation is. It is therefore convenient in all Places to find it; and this may be done several Ways: But by none more readily, more easily, or more exactly, than by the universal Dial, as made now by Mr. HEATH, the Instrument-Maker mentioned before.

This Dial's Pedestal consists of a Box and Needle, having Conveniencies to place it truly Horizontal, and in that Position to turn round on this Pedestal. The Ring representing the Meridian, is divided into Degrees, and hath a Provision made to elevate it to any Latitude North or South. The Ring representing the Equinoctial, is divided into Hours, Halves, Quarters or Minutes, according to its Largeness. The Bridge hath on one Side the Days of the Month, and on the other, the Sun's Place and Declination.

In Time of Observation; the Latitude of the Place on the Meridian must be brought to the Index; the Slider on the Bridge must be brought to either the Day of the Month, the Sun's Declination, or the Sun's Place, and then it will accordingly shew the other Two. The Equinoctial Circle must be thrust out of the Meridian, till it is at right Angles to it. Bring the Beginning of the Degrees on the Horizontal Part to the Index there. Turn the whole about upon the Three Feet, till the Sun shines equally on both Faces

of

of the Plane of the Meridian, and then level it. And so shall the Dial be duly rectified for Observation.

Then keeping the Three Feet in the same Place, turn the Dial about, till the Spot of Light passing thro' the Hole in the Slider, falls on the Circle which is divided into Hours, &c. in the Middle of the Inside of that Ring which represents the Equinoctial, among the Morning Hours, if before Noon, and among the Evening Hours, if after Noon; then will the Dial shew these following very useful and pleasant Problems.

1. The Spot of Light points out exactly the Hour of the Day. 2. The Circle representing the Meridian, lies exactly in the Plane of the Celestial Meridian; and so a Thread stretch'd over either Face of it draws a true Meridian Line. 3. The Middle of the Bridge points exactly to the true Poles. 4. The Needle in the Box shews the Variation by its End's Distance from the Beginning of the Degrees there marked; and is Westward, if the North End of the Needle be to the Left-hand of the Beginning of those Degrees, but Eastward when to the Right. 5. The Index on the Horizon, points out the Sun's *Azimuth*. 6. Turn the Meridian about upon the Plane of the Horizon, till the Sun shines equally on both its Faces as at first, the Three Feet still standing in the same Place, and elevate or depress the Sights, till the Spot of Light coming thro' the uppermost falls exactly in the little Hole in the undermost; then the Index in the *Zenith*, points to the Sun's *Altitude*, among the Divisions of the Meridian.

If a strait Ruler, whose Sides are parallel, be applied to a Wall, on which a Vertical Dial is designed to be drawn, and the Two Feet of the Dial mark'd A, A, be applied to the other Edge of the Ruler; and the Dial be rectified to the Latitude of the Place, and the Day of the Month, and levelled, and the upper Part of the Instrument be turn'd about till the Spot of Light fall as before; then the Index on the Horizon will give the Situation of that Wall, usually called by Diallers, The Declination of the Plane. Or, apply the Legs A, A, to the Ruler, and turn the upper Part about, till the North End of the Needle points at the Variation, and then, as before, you may see the Situation.

This curious Instrument is of great Use for the Regulation of Clocks and Watches, by the Help of the apparent Time observed by it (as taught above) and the

the Equation of Time engraved on the Horizontal Part of the Pedestal.

It is also a very ready Instrument for Seating an Horizontal Dial duly: For after the apparent Time is found by it, and the Horizontal Dial so seated, that it may be turned about, and still be parallel to the Horizon; turn it so about, that the Sun shining thereon, it shews the same Hour that the universal Dial shews, and then it is truly placed, and may be there fixed to the Pedestal.

And because the Latitude of the Place where the Instrument is used, must be known; there is engraved on the Backside of the Meridian, or the under Side of the Pedestal, the Latitudes of the Cities, and most remarkable Towns in *England*, and the other Parts of *Europe*.

But if any Gentleman pleases to communicate to the Workman, the Latitudes of his Country Seats, they may be particularly laid down on it.

Or if any Gentleman about to travel, is pleased to communicate the Tour he designs to take, he may have a Catalogue of the Towns in his way and their Latitudes, from Mr. *Heath*, with the Instrument, in order to ease him of Trouble of Searching Maps, Globes, or Geographical Books.

He that hath not this Dial, may find the Variation by the *Theodolite*, thus: Take the Bearing of the Sun exactly at 12 at Noon, and the North End of the Needle gives the Variation.

Or, take the Bearing of the Sun, either Rising or Setting; and then, by Trigonometry, as the Sine of the Complement of the Latitude, is to the Sine of the Declination, so is the Sine of 90 Degrees to the Sine of the Sun's Distance from the East at Rising, and from the West at Setting; and is always Southerly, when the Declination is South, and Northerly when North. And as much as this Distance differs from that observed by the Instrument, so much is the Variation: And if the Bearing taken by the Instrument be to the Left-hand of that calculated, it is Westerly, otherwise Easterly.

Or it may be found, by an Horizontal Dial, duly seated, without the Sun; if you stretch a Thread on that Dial's Meridian Line, and the Instrument placed near it, you turn the Index about, till the Telescope is parallel to that Thread; for then the Bearing shewn by the North End of the Needle is the Variation.

Beside

Beside the preceding Uses of this Dial; it may, with a very small Addition, be applied in all Respects as a *Theodolite*, or *Circumferentor*; or this Dial may be aptly and easily mounted on a *Theodolite*, and to be taken off at Pleasure.

There is one Inconvenience, usually attends the Use of these Instruments, which in this may be remedied: From about an Hour before, to an Hour after Noon, the Passage of the Spot of Light over the Equinoctial, forms with it so acute an Angle, that it is not very easy to observe the Point where it crosses it; and consequently, the preceding Problems cannot be so exactly performed. And just at Noon, the Thickness of the Brass, shades the Slider and Bridge; and so no Observation at all can be made.

In this Case, bring the Beginning of the Degrees to the Index on the Horizontal Part, and let the Hour be taken by the Instrument some Time before, which is remote from Noon, whether before or after, on the Board of the Window of your Study, where you design to use it; the Index all the while pointing to the Beginning of the Degree. Lay a strait Ruler to touch the Feet mark'd A, A; and by its Edge, draw on the Window Board a strait Line, or make Two Points where that strait Line should be drawn: And then, at any Time that is very near Noon, by laying the Ruler to the Line or Points, bringing the Beginning of the Degrees on the Horizontal Part of the Pedestal to the Index, and applying the Feet A, A, to the Edge of the Ruler as before; if you rectify the Instrument to the Latitude and Day, you may see the true Time either before or after Noon; and just at Noon, the Middle of the under Part of the Meridian will be shaded by the upper; and consequently the Time of Noon, is known, and determined whether it be before or after Noon.

If you are in a strange Place, and the Time be very near Noon; level the Instrument, and turn it about till the North End of the Needle points at the Variation, and then it is duly placed, and you may work as in the last.

Much more might be said of this Instrument's Use, but I have already outrun my designed Length and therefore must make An

E N D.



